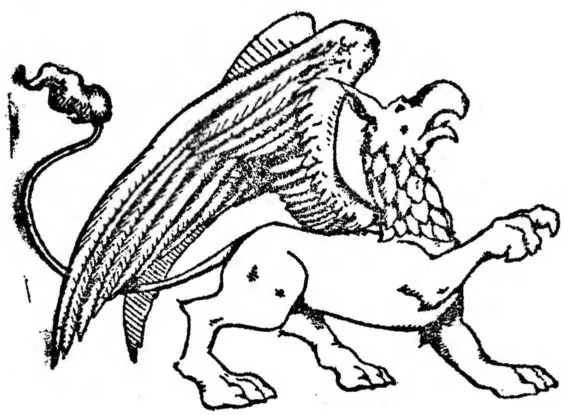
PUBLICATION NO. 980513

OPERATORS MANUAL

6000
MICROPROCESSING DIGITAL MULTIMETER



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WARRANTY

Within one year of purchase, Racal-Dana will repair or replace your instrument, at our option, if in any way it is defective in material or workmanship. The instrument must be returned to the country of purchase, unless prior arrangement has been made, and Racal-Dana Instruments will pay all parts and labor charges. Just call Racal-Dana Customer Service at (714) 859-8999 in U.S.A., (0703) 843265 in England, (1) 3-955-8888 in France, 06102-2861/2 in Germany or (02) 5062767, 5052686, or 503444 in Italy for assistance. We will advise you of the proper shipping address for your prepaid shipment. Your instrument will be returned to you freight prepaid.

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FOR YOUR SAFETY

Before undertaking any maintenance procedure, whether it be a specific troubleshooting or maintenance procedure described herein or an exploratory procedure aimed at determining whether there has been a malfunction, read the applicable section of this manual and note carefully the **WARNING** and **CAUTION** notices contained therein.

The equipment described in this manual contains voltage hazardous to human life and safety and which is capable of inflicting personal injury. The cautionary and warning notes are included in this manual to alert operator and maintenance personnel to the electrical hazards and thus prevent personal injury and damage to equipment.

If this instrument is to be powered from the AC line (mains) through an autotransformer (such as a Variac or equivalent) ensure that the common connector is connected to the neutral (earthed pole) of the power supply.

Before operating the unit ensure that the protective conductor (green wire) is connected to the ground (earth) protective conductor of the power outlet. Do not defeat the protective feature of the third protective conductor in the power cord by using a two conductor extension cord or a three-prong/two-prong adaptor.

Maintenance and calibration procedures contained in this manual sometimes call for operation of the unit with power applied and protective covers removed. Read the procedures carefully and heed Warnings to avoid "live" circuit points to ensure your personal safety.

Before operating this instrument:

1. Ensure that the instrument is configured to operate on the voltage available at the power source. See Installation Section.

2. Ensure that the proper fuse is in place in the instrument for the power source on which the instrument is to be operated.

3. Ensure that all other devices connected to or in proximity to this instrument are properly grounded or connected to the protective third-wire earth ground.

If at any time the instrument:

- Fails to operate satisfactorily
- Shows visible damage
- Has been stored under unfavorable conditions
- Has sustained stress

It should not be used until its performance has been checked by qualified personnel.

AMENDMENT
SLIDE RACK-MOUNT KIT INSTALLATION INSTRUCTIONS
NOVEMBER, 1987

In recent slide rack-mount kits, the front and rear rack-brackets are the same size and each has only one screw slot. Otherwise, the installation procedure remains as described in the manual.

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1.1 INTRODUCTION.

1.1.1 This manual contains the operating instructions for the Racal-Dana Model 6000 Microprocessing Digital Multimeter. This section of the manual contains a base description of the operating features of the instrument along with the technical specifications. Section 2 of this manual contains unpacking and installation instructions along with details necessary for system connection. Section 3 contains the operating instructions. These operating instructions include illustrations and the description of all controls, connectors and indicators on the front and rear panels of the instrument. Also included is a description of the operating characteristics and step by step operating instructions for each mode and feature of the instrument. A calibration check is also included in Section 3 for the convenience of operating personnel who desire to verify that the instrument is operating properly and that it is operating within its specifications.

1.1.2 The instrument is designed to operate with the IEEE-488-1975 General Purpose Interface Bus. The device dependent messages for operating the Model 6000 DMM in the remote mode are also included in Section 3 along with addressing instructions and a description of the system communication format and sequence.

1.1.3 Section 4 contains the laboratory calibration procedure. The laboratory calibration routine is designed to prompt the operator and the laboratory cal procedure provided in Section 4 is designed to operate step by step with pre-programmed Digical™ digital calibration sequence built into the instrument.

1.2 DESCRIPTION.

1.2.1 The Racal-Dana Model 6000 Microprocessing Digital Multimeter is a 6 1/2 digit "delayed dual sloped" instrument capable of measuring DC volts on 6 ranges, AC volts on 4 ranges and resistance on 9 ranges. The instrument will automatically select the correct range if operated in the autorange mode or a specific range may be selected manually by the operator. It is equipped with a selectable input filter which may be used to reduce possible error when making measurements in an electrical noise environment.

1.2.2 It is equipped to make resistance measurements conveniently in the 2-wire resistance mode. It may be selected simply by setting a front panel switch to the 2-wire mode position. If the accuracy of a 4-wire resistance measurement is required, the front panel switch is set to the 4-wire position and the unknown resistance is connected to the ohms source terminals on the front of the instrument and to the input terminals by separate lead pairs.

1.2.3 The input terminals of the measurement circuits are floating but the low side of the input terminals may be easily connected to guard through use of a front panel switch.

1.2.4 Bench operation is controlled by the operator through use of a front panel keyboard. For a system operation the instrument is connected through a standard GPIB interface connector on the rear panel.

1.2.5 In addition to voltage and resistance measurements the instrument is capable of measuring the ratio between voltages connected to the front panel input terminals and input terminals located on the rear panel. If the optional AC converter is used the instrument will calculate AC/DC. DC/AC, and AC/AC ratios. The instrument is not restricted to a single range, e.g., the 10 volt range for ratio measurements; the operator can select any range for making ratio measurements. The DMM is also capable of measuring the ratio between a resistance and AC or DC voltage (with the voltage source used as the reference). With the True RMS AC converter and ohms option more than 70 combinations of ratio functions and ranges can be commanded from the keyboard or over the IEEE 488 interface.

1.3 SPECIFICATIONS.

1.3.1 The specifications are given in Table 1.1

Table 1.1 - Specifications

DC VOLTS (Included In Basic Instrument)	
Ranges:	± 100.000 mV, ± 1.00000, ± 10.0000, ± 100.000, ± 1000.00V
Resolution:	0.001% Range on 5 1/2 Digit Mode 0.0001% Range on 6 1/2 Digit Mode
Overrange:	60% except 1000V Range. 1100V DC, 1500 Peak AC.
Maximum Input Voltage:	1100V DC or 1500V Peak AC All Ranges
Accuracy:	(5 1/2 digit mode, after Auto-Cal, following two hour warm-up).
24 Hours, 23°C ± 1°C	
10V Range	± 1 Digit
1,100,1000V Ranges	±(.001% Input + 1 Digit)
100mV Ranges	±(.002% Input + 5 Digits)
90 Days, 23°C ± 5°C	
10V Range	±(.001% Input + 1 Digit)
1,100,1000V Ranges	±(.002% Input + 1 Digit)
100mV Range	±(.003% Input + 5 Digits)
1 Year, 23°C ± 5°C	
10V Range	±(.003% Input + 1 Digit)
1,100,1000V Ranges	±(.004% Input + 1 Digit)
100mV Range	±(.005% Input + 5 Digits)
Temperature Coefficient:	(0°C to 50°C, 5 1/2 digit mode, after Auto-Cal, after temperature change)
10V Range	±(1.5 ppm + .05 Digit)/°C
1,100,1000V Range	±(3 ppm + .1 Digit)/°C
100mV Range	±(4 ppm + .5 Digit)/°C
Non-Linearity: 23°C ± 5°/C	All Ranges ≤ 1.0 Digit to 160% F.S. in 5 1/2 Digit Mode

DC VOLTS continued	
Input Impedances:	100 mV, 1V, 10V Ranges: > 10,000MΩ 100V, 1KV Ranges: 10MΩ
Input Bias Current:	≤ 30 pA at 23°C
Input Bias Current TC:	Doubles Every 10°C
Normal Mode Rejection:	
Unfiltered	48 dB at Multiples of 60 Hz
Filtered	100 dB at 60 Hz
Settling Time:	
Unfiltered	Analog output settles to within 0.01% of final value in 5 msec with 10K source; 10 msec on 100V range.
Filtered	Analog output settles to within 0.01% of final value in 450 msec with 10K source on all ranges.
Common Mode Rejection: (With 100Ω Unbalance in either Lead)	
Unfiltered	140 dB DC 120 dB at 61 Hz and Below Plus an Additional 54 dB at Harmonics of 60 Hz
Filtered	140 dB DC to 61 Hz 126 dB 61 Hz to 100 KHz

DC MILLIVOLTS (Option 41)	
Ranges:	± 10 mV
Resolution:	.001% F.S. (100 nV)
Overrange:	120% (Reads 22 mV input with no degradation of accuracy)
Maximum Input Voltage:	350V DC or 250V RMS
Input Impedance:	100 MΩ minimum shunted by 4.8 KΩ in series with 1.5 μF
Input Bias Current:	300 pA Typical at 23°C
Normal Mode Rejection:	Same as DC Function
Common Mode Rejection:	Same as DC Function

Table 1.1 - Specifications (continued)

DC MILLIVOLTS continued	
Settling Time, Unfiltered:	Analog output settles to within .01% of final value in 850 msec with up to 10KΩ source resistance.
Accuracy:	(5 1/2 digit mode, after Auto-Cal, following two hour warm-up. With source resistance ≤ 1KΩ and input zeroed by pushing NULL with shorted input leads.)
24 Hours, 23°C ± 1°C	
10mV Range	±(.005% Input + 5 Digits)
90 Days, 23°C ± 5°C	
10mV Range	±(.008% Input + 5 Digits)
1 Year, 23°C ± 5°C	
10mV Range	±(.01% Input + 5 Digits)
Temperature Coefficient:	(0°C to 50°C, 5 1/2 digit mode, after Auto-Cal, after temperature change. With source resistance ≤ 1KΩ and input zeroed by pushing NULL with shorted input leads.)
10mV Range	±(.002% Input + .5 Digit)/°C

OHMS (Option 24)	Standard on Models 6001, 6002
Ranges:	1.00000Ω with Option 41 10.0000Ω, 100.000Ω, 1.00000KΩ, 10.0000KΩ, 100.000KΩ, 1.00000MΩ, 10.0000MΩ, 100.000MΩ
Resolution:	0.001% F.S. in all Ranges, 5 1/2 Digit Mode 0.0001% F.S. in all Ranges, 6 1/2 Digit Mode
Overrange:	60% on all Ranges
Maximum Input Voltage:	± 350V Peak on 1Ω Range ± 500V Peak on 10Ω–100MΩ
Measurement Scheme:	Modified 4-Wire

OHMS continued	
Accuracy:	(5 1/2 digit mode, after Auto-Cal, following two hour warm-up)
24 Hours, 23°C ± 1°C	
1Ω Range	±(.015% Input + 50 Digits)*
10Ω Range	±(.003% Input + 5 Digits)**
100Ω - 1MΩ Ranges	±(.002% Input + 1 Digit)
10MΩ Range	±(.01% Input + 1 Digit)
100MΩ Range	±(.02% Input + 1 Digit)
90 Days, 23°C ± 5°C	
1Ω Range	±(.02% Input + 50 Digits)*
10Ω Range	±(.005% Input + 5 Digits)**
100Ω - 1MΩ Ranges	±(.003% Input + 1 Digit)
10MΩ Range	±(.03% Input + 1 Digit)
100MΩ Range	±(.03% Input + 1 Digit)
1 Year, 23°C ± 5°C	
1Ω Range	±(.03% Input + 50 Digits)*
10Ω Range	±(.006% Input + 5 Digits)**
100Ω - 1MΩ Ranges	±(.004% Input + 1 Digit)
10MΩ Range	±(.04% Input + 1 Digit)
100MΩ Range	±(.04% Input + 1 Digit)
Temperature Coefficient:	(0°C to 50°C, 5 1/2 digit mode, after Auto-Cal, after temperature change.)
1Ω Range	±(.002% Input + 2 Digits)/°C
10Ω Range	±(.0008% Input + .5 Digit)/°C
100Ω - 1MΩ Ranges	±(.0007% Input + .1 Digit)/°C
10MΩ Range	±(.003% Input + .1 Digit)/°C
100MΩ Range	±(.005% Input + .1 Digit)/°C
Open Circuit Voltage:	1Ω Range: 24V Max 10Ω to 1KΩ Range: 8V Max 10KΩ to 100MΩ Range: 24V Max
Current Through Unknown:	1Ω, 10Ω, 100Ω Ranges: 10 mA 1KΩ, 10KΩ Ranges: 1 mA 100KΩ Range: 100μA 1MΩ Range: 10μA 10MΩ Range: 1μA 100MΩ Range: 100 nA
Normal Mode Rejection:	
Unfiltered	48 dB at Multiples of 60 Hz
Filtered	100 dB at 60 Hz

* When making measurements in the 1Ω range, it is necessary to let the measurement circuit (DMM leads and Rx) stabilize with the + ohm source lead open before initiating a null command. (≈ 2 minutes stabilization time is required).

** after null

Table 1.1 - Specifications (continued)

OHMS continued	
Settling Time: To Rated Accuracy	1Ω Range: 1 Second 10Ω to 10MΩ Ranges: 30 mSec 100MΩ Range: 300 mSec
Ohms Guard:	Use "Analog Out" Low on Rear Panel when in Ohms

ANALOG SIGNAL OUTPUT	
General Description:	Input scaled and buffered. DC voltage is available for driving a recorder
Output Impedance:	Less than 0.5Ω
Current Available:	1 mA maximum. Protected if output is shorted
Over-Voltage:	Output clamped with diodes (no current limit) to ± 24V
Settling Time:	Same as Function selected

HARDWARE RATIO (OPTIONS 11 & 34)	
Signal Input:	Any voltage range front or rear input terminals as selected
Reference Input:	Rear reference input terminals

DC REFERENCE (OPTION 34)	
Readout:	Signal Input ÷ Ref Input Ratios are displayed in scientific notation.
Signal Ranges:	Same as Selected Function
Reference Polarity:	Positive Only
Signal Polarity:	Bipolar
Reference Voltage Range:	+1V to +10.5V
Reference Common Mode Voltage Range:	Voltage between + Ref In and – Sig In less than ± 15V
Maximum Signal Voltage:	Same as Selected Function

HARDWARE RATIO continued DC REFERENCE continued	
Reference Input Impedance: Both leads with respect to -Sig In	$10^9\Omega$ minimum (+ Lead) $3.3 \times 10^7\Omega \pm 10\%$ (– Lead)
Reference Input Bias Current: Either Lead	Less than 7 nA
Reference Settling Time:	Settles to .01% of final value in 50 msec
Accuracy: After Auto Cal with reference voltage applied	DC/DC Ratio Same as DC Accuracy (see Section 4) with error multiplied by $\left[\frac{10V}{REF\ V}\right] \times 2$ AC/DC Ratio Same as AC Accuracy with error multiplied by $\left[\frac{10V}{REF\ V}\right] \times 2$
Noise	(Noise of function) x $\frac{10V}{Ref\ V}$

AC REFERENCE (OPTION 11)	
Readout:	Signal input ÷ reference input Ratios are displayed in scientific notation.
Reference Ranges:	1V, 10V, 100V, 1000V RMS
Signal Ranges:	Same as Selected Function
Maximum Reference Voltage:	1000V RMS or 1500V Peak
Maximum Signal Voltage:	Same as Selected Function
Reference Voltage Range:	10% of F.S. to 160% F.S. except 1000V Range which is 10% to 100% of F.S.
Reference Input Impedance:	Same as AC Option 10
Ratio Accuracy: (Up to 10 KHz)	(Accuracy of Function) + (Accuracy of Option 10) The sum multiplied by $\frac{\text{Reference Range}}{\text{Reference Input}}$
Frequency Range:	20 Hz to 10 KHz
Reference Temperature Coefficient: (0°C to 50°C) After Auto-Cal	±(0.004% RDG + 0.005% F.S.)/°C

Table 1.1 - Specifications (continued)

AC VOLTS TRUE RMS (Option 10)	Standard on Model 6002
Ranges:	1.00000V, 10.0000V RMS 100.000V, 1000.00V RMS
Resolution:	0.001% of Range
Maximum Input Voltage:	1000V RMS or 1500V Peak, decreasing to 50V RMS at 300 KHz. (1.5×10^7 V)(Hz) max. any Range.
Settling Time: Zero to F.S. "Filter" Out "Filter" In F.S. to 10% F.S. "Filter" Out "Filter" In	Settles to within 0.1% of Range: 80 mSec 350 mSec Settles to within 0.1% Range: 100 mSec 400 mSec
Input Impedance:	1MΩ in series with .22 μF, shunted by less than 200 pF to common. In DC coupled mode the .22 μF capacitor is shorted.
Common Mode Rejection: 100Ω Unbalance either lead. DC to 60 Hz	Range / CMRR 1V 120 dB 10V 100 dB 100V 80 dB 1000V 60 dB
Accuracy:	(After Auto-Cal, following two hour warm-up, sinewave input.) Vin ≤ 500V 0.1% F.S. < Vin ≤ 160% F.S. For Vin > 500V, add 0.1% of RDG to specification.
24 Hours, 23°C ± 1°C	
20 Hz - 30 Hz (Filt.)	±(.5% Input + 50 Digits)
30 Hz - 50 Hz (Filt.)	±(.2% Input + 50 Digits)
50 Hz - 100 Hz (Filt.)	±(.1% Input + 50 Digits)
100 Hz - 20 KHz (Filt.)	±(.06% Input + 50 Digits)
200 Hz - 20 KHz (Unfilt.)	±(.06% Input + 50 Digits)
20 KHz - 50 KHz (Both)	±(.09% Input + 100 Digits)
50 KHz - 100 KHz (Both)	±(.38% Input + 180 Digits)
100 KHz - 300 KHz (Both) (10V, 100V, 1000V Ranges)	±(3% Input + 500 Digits)
100 KHz - 300 KHz (Both) (1V Range)	±(5% Input + 1000 Digits)

For full accuracy above 150 VAC the FILTER should be selected.

AC VOLTS continued	
90 Days, 23°C ± 5°C	
20 Hz - 30 Hz (Filt.)	±(.5% Input + 60 Digits)
30 Hz - 50 Hz (Filt.)	±(.21% Input + 60 Digits)
50 Hz - 100 Hz (Filt.)	±(.11% Input + 60 Digits)
100 Hz - 20 KHz (Filt.)	±(.07% Input + 60 Digits)
200 Hz - 20 KHz (Unfilt.)	±(.07% Input + 60 Digits)
20 KHz - 50 KHz (Both)	±(.1% Input + 100 Digits)
50 KHz - 100 KHz (Both)	±(.4% Input + 200 Digits)
100 KHz - 300 KHz (Both) (10V, 100V, 1000V Ranges)	±(3% Input + 500 Digits)
100 KHz - 300 KHz (Both) (1V Range)	±(5% Input + 1000 Digits)

For full accuracy above 150 VAC the FILTER should be selected.

6 Months, 23°C ± 5°C	
20 Hz - 30 Hz (Filt.)	±(.52% Input + 70 Digits)
30 Hz - 50 Hz (Filt.)	±(.22% Input + 70 Digits)
50 Hz - 100 Hz (Filt.)	±(.12% Input + 70 Digits)
100 Hz - 20 KHz (Filt.)	±(.08% Input + 70 Digits)
200 Hz - 20 KHz (Unfilt.)	±(.08% Input + 70 Digits)
20 KHz - 50 KHz (Both)	±(.11% Input + 110 Digits)
50 KHz - 100 KHz (Both)	±(.42% Input + 220 Digits)
100 KHz - 300 KHz (Both) (10V, 100V, 1000V Ranges)	±(4% Input + 600 Digits)
100 KHz - 300 KHz (Both) (1V Range)	±(6% Input + 1100 Digits)

For full accuracy above 150 VAC the FILTER should be selected.

Temperature Coefficient:	±(0.004% RDG + 0.005% F.S.)/°C
Crest Factor:	7:1 at full scale $7 \times \sqrt{\frac{F.S.}{V_{IN}}}$ for other voltages

Table 1.1 - Specifications (continued)

AC VOLTS AVERAGING (Option 14)	
Ranges:	1.00000V, 10.0000V, 100.000V, 1000.00V
Resolution:	.001% of Range
Maximum Input Voltage:	1000V RMS or 1500V Peak, decreasing to 20V RMS at 1 MHz. ($2x10^7$ V)(Hz) max any Range.
Settling Time:	Settles to within rated accuracy of range:
Zero to F.S.	
"Filter" Out	200 msec
"Filter" In	600 msec
F.S. to 10% F.S.	
"Filter" Out	200 msec
"Filter" In	600 msec
Input Impedance:	1MΩ in series with .22μF, shunted by less than 100 pF to common.
Common Mode Rejection: 100Ω Unbalance either lead. DC to 60 Hz	Range / CMRR
	1V 120 dB
	10V 100 dB
	100V 80 dB
	1000V 60 dB
Accuracy:	(After Auto-Cal, following two hour warm-up, sinewave input.) Vin ≤ 500V 0.1% F.S. < Vin ≤ 160% F.S. For Vin ≥ 500V, add 0.1% of RDG to specification for f ≤ 5 KHz; add 0.2% of RDG for f > 5 KHz.
24 Hours, 23°C ± 1°C	
20 Hz - 30 Hz (Filt.)	±(.3% Input + 2 Digits)
30 Hz - 50 Hz (Filt.)	±(.2% Input + 2 Digits)
50 Hz - 100 Hz (Filt.)	±(0.05% Input + 2 Digits)
100 Hz - 5 KHz (Filt.)	±(.03% Input + 2 Digits)
300 Hz - 5 KHz (Unfilt.)	±(.03% Input + 2 Digits)
5 KHz - 50 KHz (Both)	±(.04% Input + 5 Digits)
50 KHz - 100 KHz (Both)	±(.05% Input + 10 Digits)
100 KHz - 300 KHz (Both)	±(.6% Input + 20 Digits)
300 KHz - 1 MHz (Both)	±(2.5% Input + 70 Digits)

AC VOLTS continued	
90 Days, 23°C ± 5°C	
20 Hz - 30 Hz (Filt.)	±(.31% Input + 4 Digits)
30 Hz - 50 Hz (Filt.)	±(.21% Input + 4 Digits)
50 Hz - 100 Hz (Filt.)	±(.06% Input + 4 Digits)
100 Hz - 5 KHz (Filt.)	±(.04% Input + 4 Digits)
300 Hz - 5 KHz (Unfilt.)	±(.04% Input + 4 Digits)
5 KHz - 50 KHz (Both)	±(.05% Input + 7 Digits)
50 KHz - 100 KHz (Both)	±(.06% Input + 12 Digits)
100 KHz - 300 KHz (Both)	±(.61% Input + 22 Digits)
300 KHz - 1 MHz (Both)	±(2.5% Input + 72 Digits)
6 Months, 23°C ± 5°C	
20 Hz - 30 Hz (Filt.)	±(.32% Input + 5 Digits)
30 Hz - 50 Hz (Filt.)	±(.22% Input + 5 Digits)
50 Hz - 100 Hz (Filt.)	±(.07% Input + 5 Digits)
100 Hz - 5 KHz (Filt.)	±(.05% Input + 5 Digits)
300 Hz - 5 KHz (Unfilt.)	±(.05% Input + 5 Digits)
5 KHz - 50 KHz (Both)	±(.06% Input + 8 Digits)
50 KHz - 100 KHz (Both)	±(.07% Input + 13 Digits)
100 KHz - 300 KHz (Both)	±(.62% Input + 23 Digits)
300 KHz - 1 MHz (Both)	±(2.5% Input + 73 Digits)
Temperature Coefficient:	(0°C to 50°C, after Auto-Cal, after temperature change).
50 Hz - 20 KHz (Filt.)	±(.003% Input + .5 Digit)
20 KHz - 100 KHz (Both)	±(.005% Input + 2 Digits)
100 KHz - 1 MHz (Both)	±(.02% Input + 10 Digits)

Table 1.1 - Specifications (continued)

SAMPLE & HOLD FAST A/D (OPTION 03SH) GENERAL INFORMATION (NORMAL DVM INPUT TERMINALS)	
Optional A/D converter which allows conversion at up to 34,000 readings/sec.	
Function:	Any range in DC function except millivolts (opt. 41).
Ranges:	Same as DC Function Option 41 and Ohms below 10 KΩ range not specified.
Maximum Input:	Same as DC Function
Settling Time:	Same as DC Function
Accuracy:	24 hr., 23°C ± 1°C
0V to ± Full Scale	±.05% Rdg ± 1.5 counts
± Full Scale to 160% Full Scale	±.05% Rdg ± 3 counts
	1 yr., 23°C ± 5°C
0V to ± Full Scale	±.5% Rdg ± 4 counts
± Full Scale to 160% Full Scale	±.5% Rdg ± 6 counts
Temperature Coefficient: DC Function except mV	±.015% Rdg ±.1 count/°C
Read Rate:	
With display	250 reading/sec
Without display (GPIB output)	6000 reading/sec
With external trigger pulse (negative going TTL pulse 200 ns to 20 µs in duration. Must be bounce free)	34,000 reading/sec (Does not include settling time.)
Output Format:	12 bit, two's complement
Data Scale Factor:	
Signal Directly to Fast A/D Pins 24, 25	10 mV/count ± 20.47 volts produces octal data display of ± 3777
Signal Taken From Isolator Output	Linear up to 160% of selected range. Isolator output of ± 16.00 volts produces octal data display of ± 3067
1000V Range	1V/count
100V Range	100 mV/count
10V Range	10 mV/count
1V Range	1 mV/count
100 mV Range	100 µV/count

SAMPLE & HOLD FAST A/D (OPTION 03 SH) ADDITIONAL INFORMATION	
Delay (Variable):	2 to 20 µsec.
Delay Offset: (External Trigger to Delay Out) No Delay Selected	100ns ± 30ns
Repeatability	± 2ns
Offset: Delay Out to Signal Hold (For total delay add offset to delay or delay offset)	140ns ± 20ns
Repeatability	± 3ns
03SH INPUT CONNECTOR SPECIFICATIONS (PINS 24, 25)	
Input Voltage Range	± 10 Volts DC
Max. Measureable Input:	± 20 Volts
Maximum Input Without Damage:	100 Volts DC or Peak AC
Accuracy:	24 hr., 23°C ± 1°C
0V to ± 10V	±.05% ± 1.5 counts
−10V to −20V and +10V to +20V	±.05% ± 3 counts
	1 yr., 23°C ± 5°C
0V to ± 10V	±.5% ± 4 counts
−10V to −20V and +10V to +20V	±.5 ± 6 counts
Temperature Coefficient:	±.015% Rdg ±.1 count/°C
Input Resistance:	> 100KΩ
Bandwidth (3 dB):	1 MHz
Settling Time: 20V Step, 1KΩ Source	6 µs to 30 mV
	2 µs to 200 mV

Table 1.1 - Specifications (continued)

GENERAL	
Display:	5 full decades plus overrange digit
Overrange:	60% overrange with full accuracy on all ranges and functions except: AC (1000 VAC RMS maximum) DC (1100 volts maximum) 10 mV (120% overrange) 1Ω (120% overrange)
Overrange Indication:	Display reads "OL" except in 10mV range. DMM automatically upranges when 10 mV range is overloaded.
Warm-up Time To 24 Hr. Specifications:	2 hours
Warm-up Time To Fully Stabilize To 6 Month Specifications:	1 hour
Maximum Common Mode Voltage:	1000V DC or peak AC, Guard to case with interface common tied to case. 250V, analog common to guard.
Front Panel Input Terminals:	+ signal input + I (+ Ω current output) – I (– Ω current return) – IN (– signal common) guard
Rear Panel Terminals:	+ EXT REF input EXT REF Common + INPUT (+ signal input) + I (+ Ω current output) – INPUT (– signal common) guard – I (– Ω current return) Analog Output Analog Common Ext Trigger
Ranging:	Autorange standard Uprange at 160% range (nominal) Downrange at 10% range (nominal) Manual range standard
Range of Mathematical Constants:	± 1 E-9 to ± 9999.99E9

GENERAL continued	
Power Requirements:	100, 120, 220, or 240V ± 10% 75 watts maximum 60 Hz Standard
Weight:	25 lbs. (net)
Dimensions: (See Figure 1.1)	3.5" Height x 18" Deep x 16.75" Wide
Rack Mounting:	Standard corporate package
Temperature Range:	Operating 0°C to 50°C Storage –40°C to +70°C at 80% RH
Humidity, Operating:	< 75% RH; 25°C to 40°C < 50% RH; 40°C to 50°C
Vibration - Operating:	0.025" Double amplitude to 55 Hz for 15 minutes

SYSTEMS (BCD, OPTION 59)	
Data Output Information:	All BCD outputs of display, 4-Bit Range code function flags, polarity flags, special flags, and logic supplies
Logic Type:	Low power Schottky TTL levels, 8-4-2-1 BCD
Maximum Read Rate:	13 per sec. to full scale, 33 per sec. to full scale in Superfast, 60 Hz Operation
Isolation:	Data output common may be floated up to 200V peak from power line common
Remote Programming Input Information:	Provides isolated programming of all DMM functions and ranges
Functions:	Function lines are programmed by a closure to ground (low TTL level)
Ranges:	Range lines are 8-4-2-1 coded positive true logic

Table 1.1 - Specifications (continued)

GPIB INTERFACE (Option 55 GPIB)	Standard on Models 6001, 6002
Output Information:	Numeric data, polarity, function, range, and special flags.
Input Information:	Functions, ranges, microprocessing functions. (Full control of all instrument capabilities.)
Bus Compatibility:	IEEE STD-488-1975

IEEE STD-488-1975 Subset Capability

Subset	Function	Capability
SH1	Source Handshake	Complete
AH1	Acceptor Handshake	Complete
T5	Talker	Complete
TE0	Extended Talker	None
L4	Listener	All except listen only
LE0	Extended Listener	None
SR1	Service Request	Complete
RL1	Remote/Local	Complete
PP0	Parallel Poll	None
DC1	Device Clear	Complete
DT1	Device Trigger	Complete
C0	Controller	None
E1	Open collector bus drivers	—

Handshake Times:	
Address/Universal Commands	<75µS (15µS typical)
Programming Codes	<350µS per character
Data Output	<100µS per character (<85µS/character - HSD)
Output Format:	Remote/local, addressed to talk, addressed to listen, service request, bus address

6 1/2 DIGIT MODE	
Ranges & Functions:	All ranges and functions same
Selection:	May be selected via front panel keyboard or programming via GPIB only
Display:	6 digit display with % overrange as noted for 5 1/2 digit operation
Accuracy:	Same as 5 1/2 digit

4 1/2 DIGIT MODE	
Fast integration mode, 1-2/3 msec. (60 Hz) conversion maximum (not including internal 15 msec reset)	
Integrate Time:	1-2/3 msec (60 Hz) 2 msec (50 Hz)
Ranges & Functions:	All ranges and functions same
Selection:	May be selected via front panel keyboard or programming
Display:	Four digit display with % over-range as noted for 5 1/2 digit operation
Accuracy:	Standard accuracy for range and function plus .03% of reading plus .03% of F.S.

READ RATES

	With Display	Without Display
6 1/2 Digit	2 readings/sec	same
5 1/2 Digit	17 readings/sec	same
4 1/2 Digit	45 readings/sec	50 readings/sec
3 1/2 Digit (Fast A/D)	250 readings/sec	6000 readings/sec

Table 1.1 - Specifications (continued)

AUTOMATIC SOFTWARE RATIO $\frac{V1}{V2}$	
Signal Input (V1):	Front input terminals*
Reference Input (V2):	Rear input terminals*
Normal Mode Rejection:	Same as for function selected for both signal (V1) and reference (V2) inputs
Isolation:	1000 megohms between any front input terminal and any rear input terminal. Max 1000V DC or 1500 peak AC from any front input terminal to any rear input terminal.
*Inputs may be reversed using front/rear input programming by keyboard and remotely	
Signal Ranges: **Reference Ranges:**	Same as selected function 1, 10, 100, 1000V DC 1, 10, 100, 1000 V AC
Accuracy - DC/DC: **Same Reference & Signal Range:** 1-1000V Range: 100mV Range:	 $\pm .001\%$ Rdg $\pm \left(.001\% \text{ F.S. } \frac{RR}{RI}\right)^*$ $\pm .001\%$ Rdg $\pm \left(.005\% \text{ F.S. } \frac{RR}{RI}\right)^*$
Different Signal & Reference Range: 1-1000V Range: 100mV Range:	 $\pm .002\%$ Rdg $\pm \left(.002\% \text{ F.S. } \frac{RR}{RI}\right)^*$ $\pm .007\%$ Rdg $\pm \left(.01\% \text{ F.S. } \frac{RR}{RI}\right)^*$
Accuracy - AC/AC: **Same Reference & Signal Range & Frequency:** 100 Hz - 20 KHz 50 Hz - 50 KHz	 $\pm .06\%$ Input $\pm \left(.05\% \text{ FS } \frac{RR}{RI}\right)^*$ $\pm .1\%$ Input $\pm \left(.1\% \text{ FS } \frac{RR}{RI}\right)^*$
Accuracy - Mixed Functions:	Signal function specification and reference function specification (with % of range multiplied by $\frac{RR}{RI}$)*
Speed:	Approximately 1 second per reading + timeouts for signal/reference functions and ranges (Max timeout approx 500 mS)

*RR = Ref. Range
RI = Ref. Input

$$\frac{RR}{RI} \geq 1$$

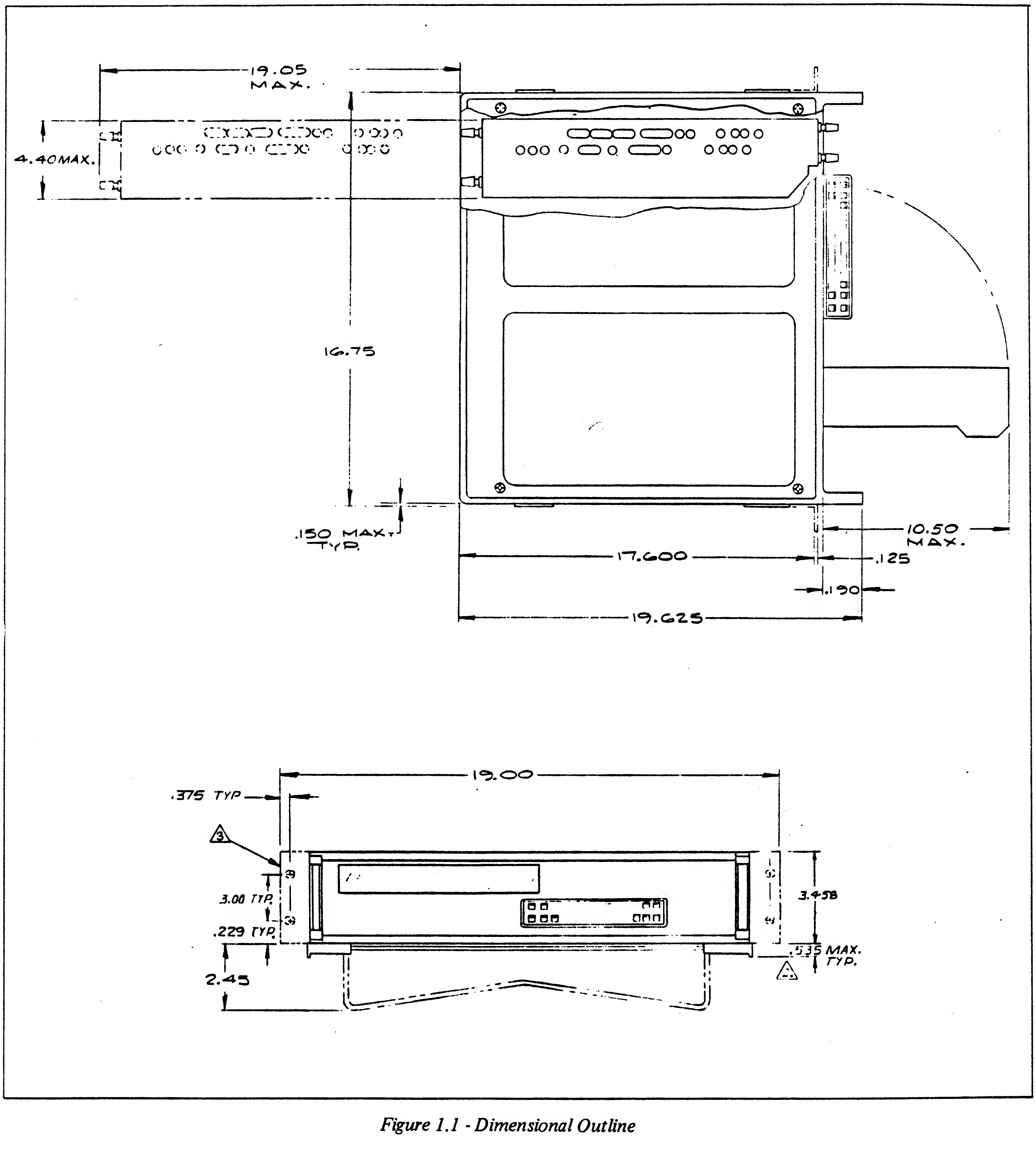


Figure 1.1 - Dimensional Outline

2.1 UNPACKING AND INSPECTION.

2.1.1 The Model 6000 DMM is packed in a molded plastic-foam form within a cardboard carton for shipment. The plastic form holds the DMM securely in the carton and absorbs any reasonable external shock normally encountered in transit. Prior to unpacking, examine the exterior of the shipping carton for any signs of damage. Carefully remove the DMM from the carton and inspect the exterior of the instrument for any signs of damage. If damage is found, notify the carrier immediately.

2.1.2 Included with the instrument in the packing container are the instruction manual and power cord.

2.1.3 For the convenience of the user during maintenance or field installation of options, the Model 6000 has an option label affixed to the transformer cover on the rear panel. It indicates the location of all option assemblies for that unit.

2.2 BENCH OPERATION.

2.2.1 Each Model 6000 is equipped with a tilt bail or "kickstand" to enable the front of the instrument to be elevated for convenient bench use. The tilt bail is attached to the two front supporting "feet" at the bottom of the instrument. For use, the bail is pulled down to its supporting position.

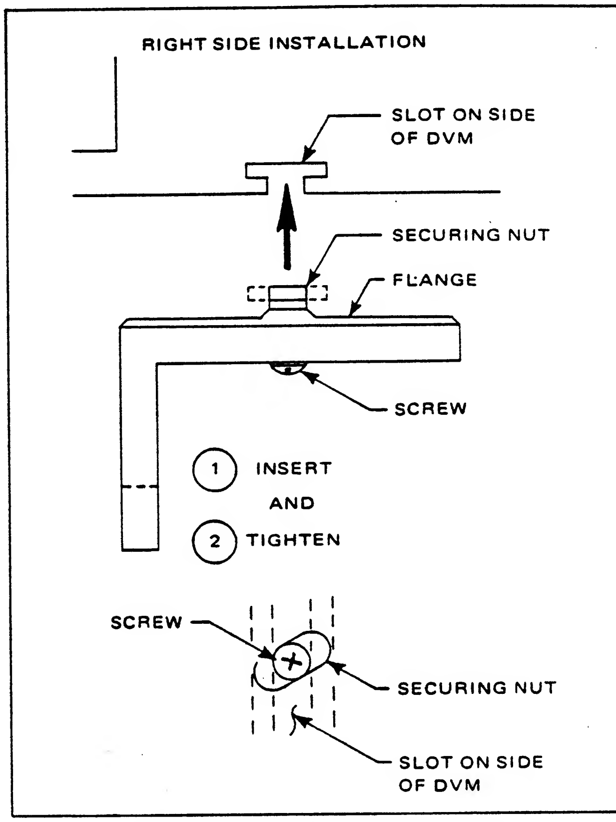


Figure 2.1 - Rack Mount Installation

2.3 RACK MOUNTING.

2.3.1 The instrument can be mounted in a standard 19-inch rack with the optional rack-mounting flanges (403402, includes attaching hardware). To install the flanges, proceed as follows:

a. With instrument on its side, remove four Phillips-head screws holding bottom cover. Remove cover. Remove screws holding feet (and bail) in place. Replace bottom cover.

b. Next, remove the Special Purpose Function tray attached to the bottom cover by lifting the four metal tabs with an appropriate tool. Replace the bottom cover.

c. Place one of the supplied screws through each of the two holes in the mounting flange (figure 2.1). Thread a securing nut onto each screw just enough to attach it to the screw (approximately one turn).

d. Place the mounting flange onto the mounting slot in the instrument side panel so that the securing nuts fit entirely into the slot. Be sure the rack-mount slots on the flange are toward the front of the instrument.

e. Tighten screws. The securing nuts will rotate and hold the flange securely in place.

2.4 POWER CONNECTIONS

2.4.1 Standard units operate on either 100, 115, 230 or 240 volts, 60 Hz (50 or 400 Hz available). Power consumption is less than 75 watts. Operation on either of the four line voltages is selectable by placement of a small printed circuit card in the combination voltage selector/fuse holder/power cord connector assembly. Selection of a specific line voltage is accomplished as follows:

a. Disconnect the AC power cord from the power connector (reference 9 , Figure 3.3, Table 3.3) and slide the plastic fuse cover to the left so that it covers the power cord connector pins. This exposes the fuse and the safety interconnect device.

b. Pull the small lever marked FUSE PULL and swing it to the left. This removes the fuse from the fuse holder and makes the voltage selector card accessible for removal.

c. Remove the voltage selector PCB and reinsert it so that the desired operating line voltage is visible.

d. Swing the lever marked FUSE PULL back to the right and snap it into the closed position.

e. Replace the fuse and slide the plastic window to the right so that it covers the voltage selector PCB and fuse.

f. Plug the AC line cord into the line cord connector. The instrument is now ready for operation.

2.4.2 A standard power cable having a three-pin plug is supplied with the instrument. It connects to POWER connector J214. The ground pin is attached to the instrument case. It is important that this pin be connected to a good quality earth ground.

2.4.3 Fuse receptacle F201 on the rear panel is equipped with a .75 amp fuse.

2.5 INPUT/OUTPUT CABLING.

2.5.1 Binding Posts.

2.5.1.1 Several connectors on the Model 6000 consist of a pair of binding posts spaced so as to accept standard "banana" plugs. The connectors are:

	Front Panel	Rear Panel
	± INPUT	± EXT REF
	± OHMS CURRENT	± INPUT
	GUARD	± 4-WIRE Ω
		GUARD
BNC CONNECTORS		EXT TRIG
BNC CONNECTORS		ANALOG OUTPUT

2.5.1.2 Input cables to fit the above connectors can be ordered from Racal-Dana. The Part Numbers are shown below:

CABLE ASSEMBLY	PART NUMBER
AC POWER	403530
INPUT 4-WIRE Ω SOURCE EXTERNAL REFERENCE	402190

2.5.2 Fast A/D Output Connector (Options 03 and 03SH).

2.5.2.1 When Option 03 or 03SH is installed the instrument is equipped with a rear panel connector for system connection of the fast analog-to-digital output. The pin-signal assignments for these connectors are illustrated in Figures 2.2 and 2.3. The instrument is supplied with the mating connector.

2.5.3 Interface Bus Connector (Option 55).

2.5.3.1 When Option 55 is installed the instrument is equipped with a General Purpose Interface Bus connector for connection to a system. The pin-signal assignments for this connector are illustrated in Figure 2.4. This connector is configured to conform to the IEEE-488-1975 Standard Interface Specification.

2.5.4 Parallel BCD Output/Program Connector (Option 59).

When the instrument is configured for remote control and parallel BCD output, data is routed out to the system through the rear panel connectors illustrated in Figures 2.5 and 2.6. This illustration shows the pin signal assignments for the parallel BCD program input connector and parallel BCD output connector.

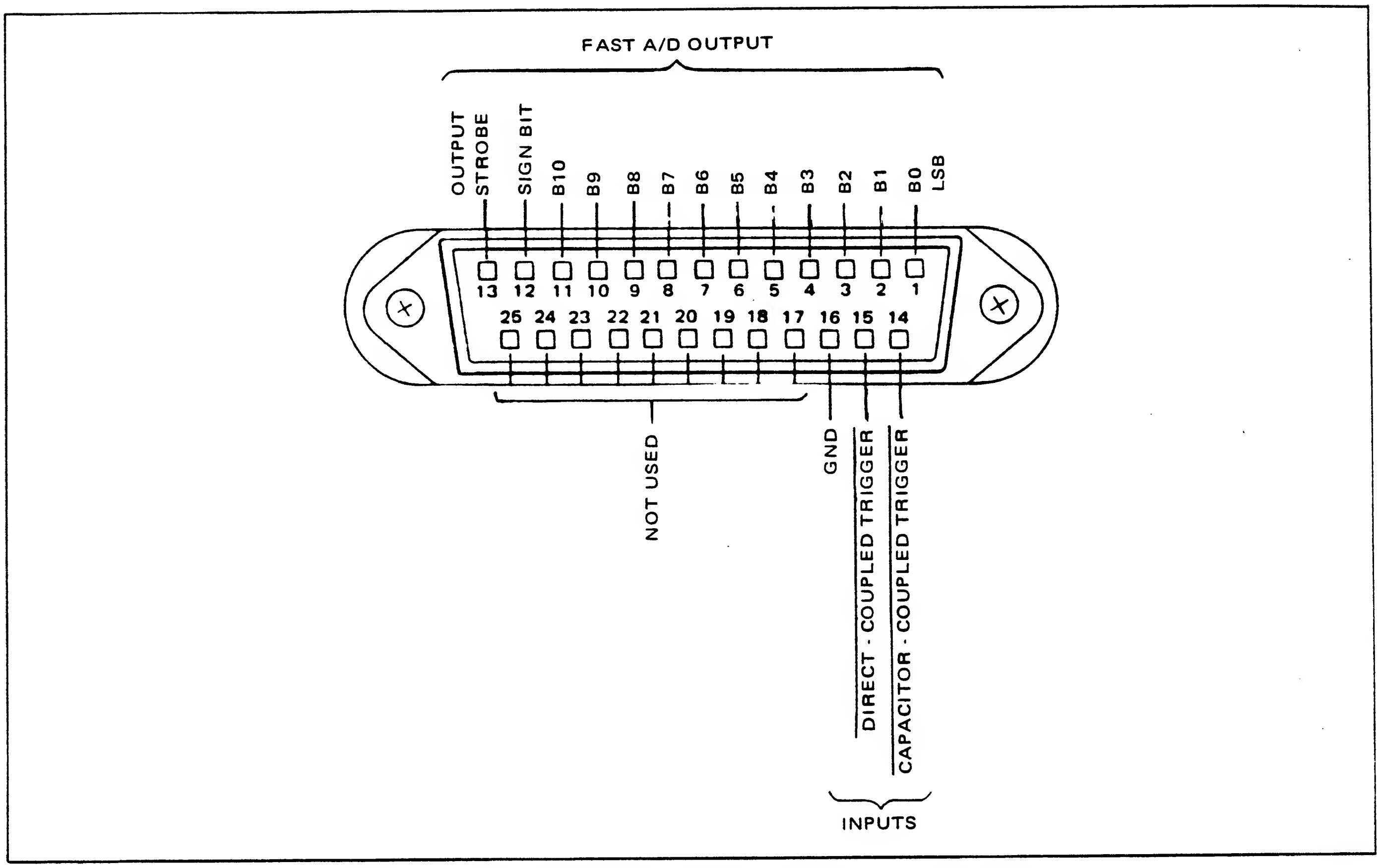


Figure 2.2 - Fast A/D Output Connector - Option 03 (Rear Panel)

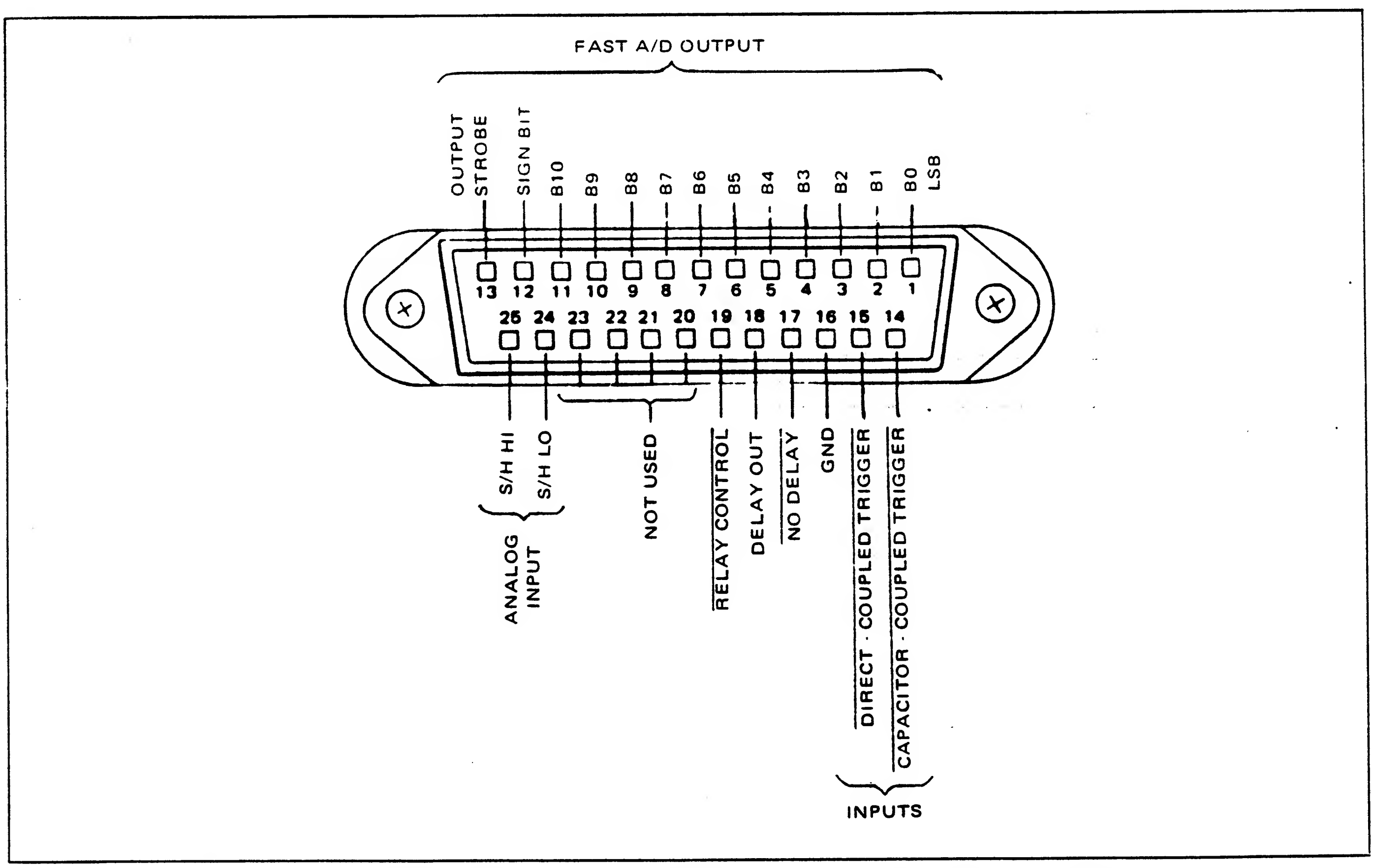


Figure 2.3 - Sample & Hold Fast A/D Output Connector - Option 03SH (Rear Panel)

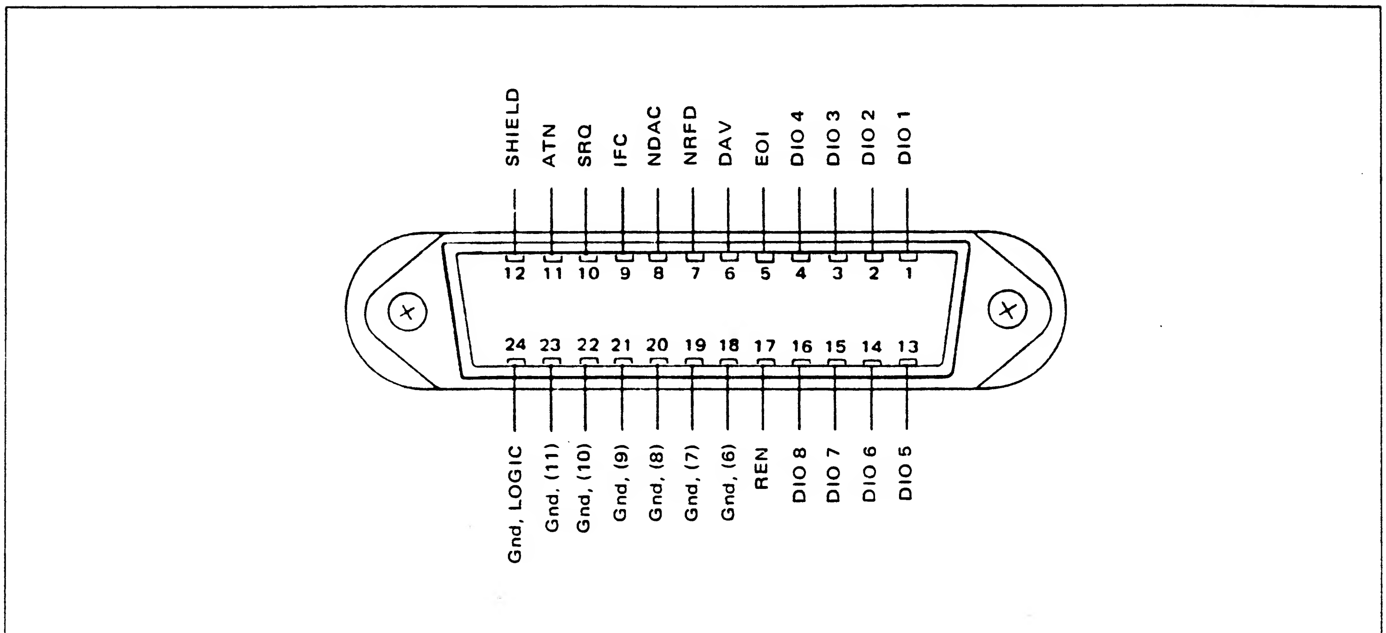


Figure 2.4 - GPIB Connector (Rear Panel)

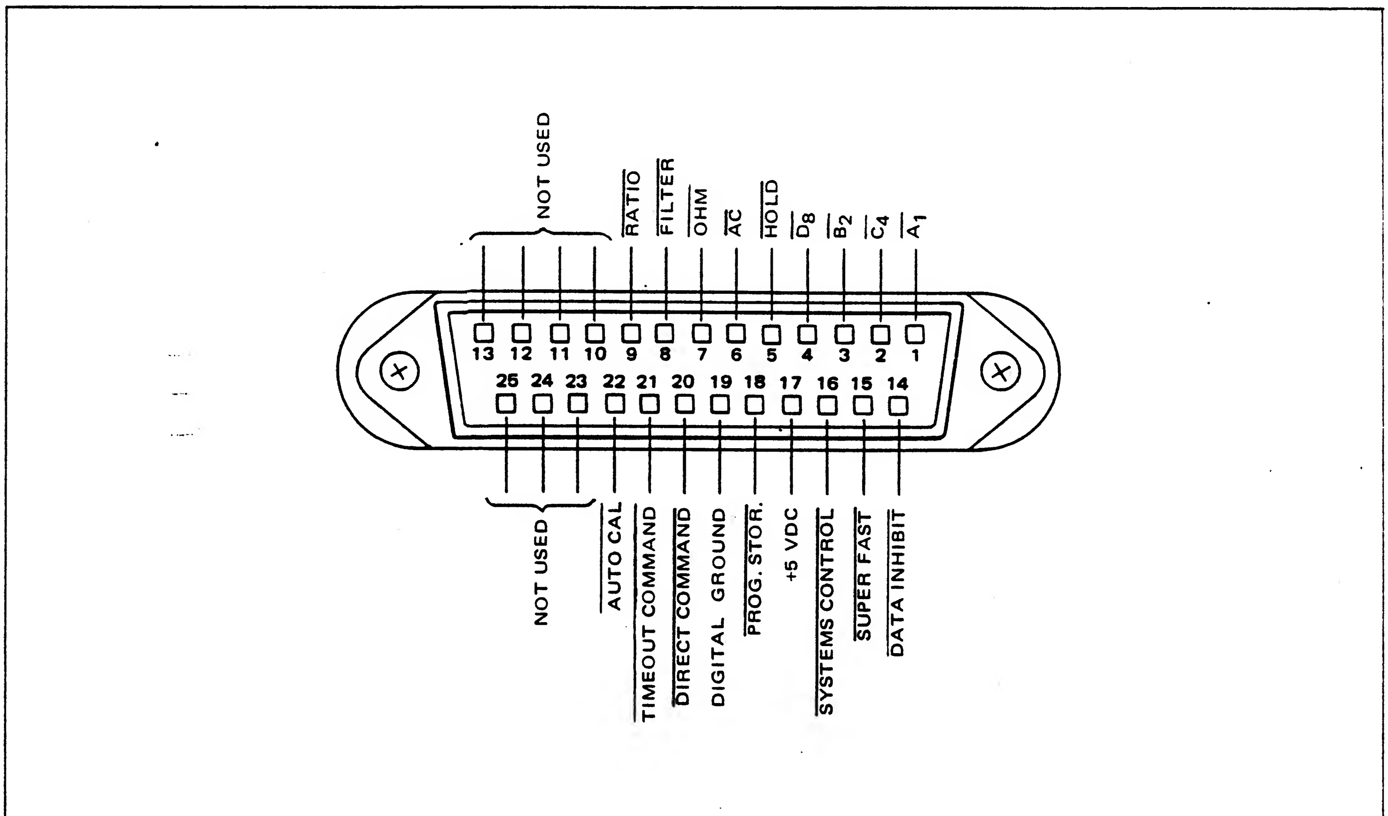


Figure 2.5 - J209 Parallel BCD Program Input Connector (Rear Panel)

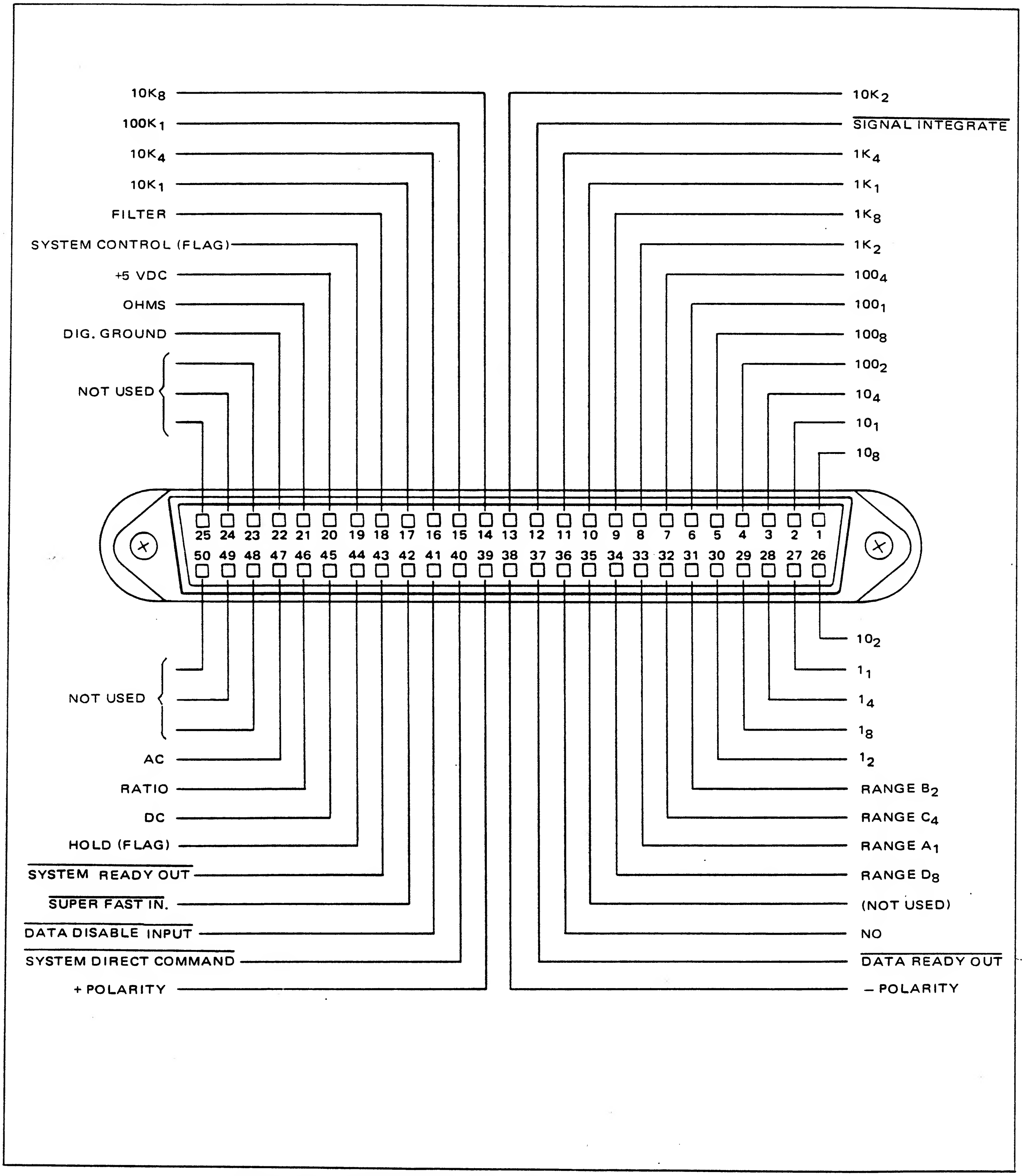


Figure 2.6 - J212 Parallel BCD Printer Output Connector (Rear Panel)

3.1 INTRODUCTION.

3.1.1 This section contains operating and calibration information for the Model 6000 DMM. The operating information contains illustrations of all front and rear panel controls, indicators and connectors along with tabular listings of the function and purpose of each. Operating instructions for manual or bench operation are presented in two ways; a description of each operating feature followed, where necessary, with a step-by-step operating example. Some operating features or functions are simple one or two step operations and thus no operating examples are included.

3.1.2 Remote operation via the IEEE-STD-488-1975 General Purpose Interface Bus is one of the principal features of the 6000 DMM and the section presents bus address selection information and a tabular listing of the device-dependent messages used to program the instrument. Also included is a GPIB program, measurement and data transfer example in tabular form. This example is a step-by-step listing of the interface command messages, data messages and interface control signal line operation required to perform a typical program and data transfer cycle. A timing diagram accompanies the GPIB program cycle to illustrate the timing relationship of the interface, handshake and data lines of the bus in operation.

3.1.4 A calibration check procedure is provided and this procedure includes step-by-step instructions for the calibration check along with illustrations showing the connection of the 6000 DMM and the calibration equipment.

3.1.5 Following the calibration check procedure is a laboratory calibration procedure. This is a step-by-step procedure providing instructions for complete calibration of the instrument.

3.2 CONTROLS, INDICATORS AND CONNECTORS.

3.2.1 The location, nomenclature and function of all controls, indicators and connectors are illustrated and described in Figures 3.1, 3.1A, 3.2 and the accompanying Tables 3.1 through 3.3. The front panel information is presented in Figure 3.1, Table 3.1; the keyboard information in Figure 3.1A, Table 3.2 and, the rear panel is shown and described in Figure 3.2 and Table 3.3.

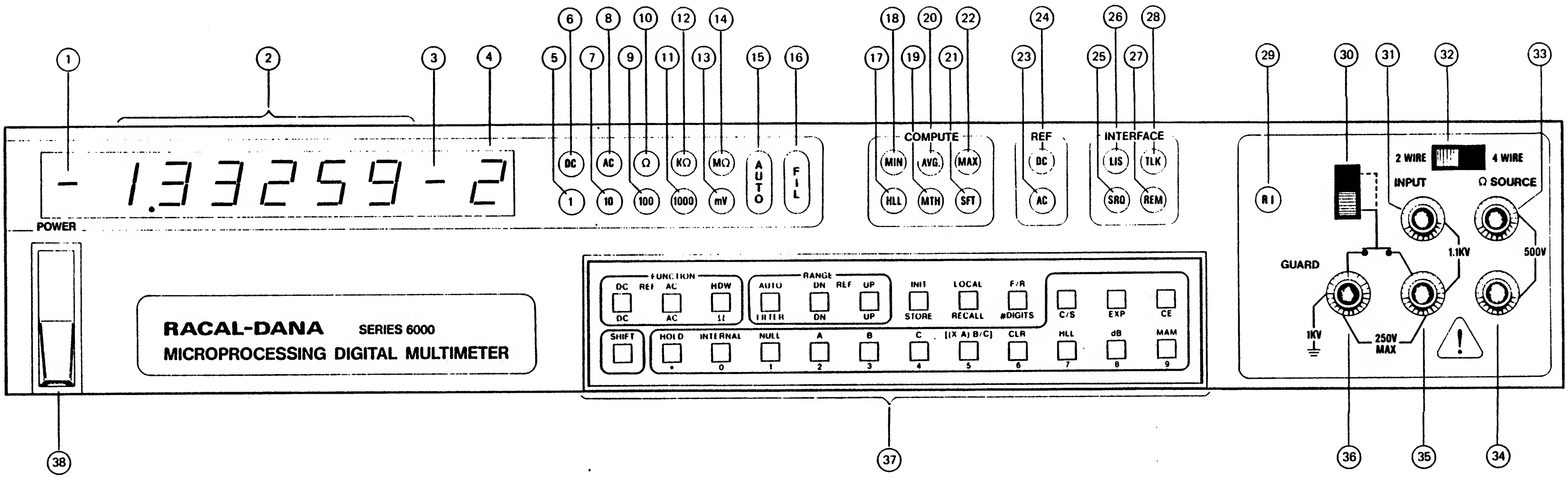


Figure 3.1 - Front Panel Controls, Indicators and Connectors

Table 3.1 - Front Panel Controls, Indicators and Connectors

Reference	Item/Position	Function
1	Mantissa sign indicator (LED)	Displays the – polarity of the mantissa appearing on the display LEDs.
2	Mantissa display LEDs	For the DC, AC and ohms functions these LEDs display the value of the measurement along with any appropriate decimal point. They are also used to display constants and function symbols such as "db", "Hi" and "Lo".
3	Exponent sign indicator	Displays the negative sign indication for the exponent.
4	Exponent indicator	Indicates the numeric value of the exponent. Also indicates LSD when in 6 1/2 digit mode.
5	1 range indicator LED	Indicates that the instrument is on the 1 volt range when on AC or DC functions or in the 1Ω, 1KΩ or 1 Megohm range in the resistance function.
6	DC annunciator	Indicates that the instrument is on the DC volt function.
7	10 annunciator	Indicates that the instrument is on the 10 volt or 10 mV range when on the AC or DC volts function or on the 10Ω. 10KΩ or 10 Megohm range in the resistance function.
8	AC annunciator	Indicates the instrument is performing an AC volts measurement function.
9	100 annunciator	Indicates the instrument is on the 100 volt or 100 mV range when performing an AC volts or DC volts measurement or on the 100Ω. 100KΩ or 100 Megohm range in the resistance function.
10	Ω annunciator	Indicates that the instrument is performing a resistance measurement function and that the display is indicating the value of the measurement in ohms.
11	1000 annunciator	Indicates that the instrument is on the 1000 volt range while performing in an AC volts or DC volts measurement.
12	KΩ annunciator	Indicates that the instrument is performing a resistance measurement function and that the value shown on the display is in kilohms.
13	mV	Indicates that the instrument is measuring DC volts and that the display is showing the voltage measurement in mV.
14	MΩ annunciator	Indicates that the instrument is performing a resistance measurement and that the display is indicating the resistance value in Megohms.
15	AUTO annunciator	Indicates that the instrument is in the auto range mode.

Table 3.1 - Front Panel Controls, Indicators and Connectors continued

Reference	Item/Position	Function
16	FIL indicator	Indicates that the input filter has been switched in the measurement input circuit.
17	HLL annunciator	Indicates that the instrument is performing the high-low-limit function. When this annunciator is lit it indicates that the display is showing a relative measurement of the value based on a preselected and preprogrammed input limit.
18	MIN annunciator	Indicates that the display is presenting the recalled minimum value measured during a min-avg-max measurement function. The min avg max are all lit when MAM routine is being used. Min lit by itself only during "Recall Min" operation.
19	MTH annunciator	Indicates that NULL or $\frac{(X-A)B}{C}$ is being used.
20	AVG annunciator	Indicates that the display is presenting the recalled average result of the min-average-maximum computation. The min avg max are all lit when MAM routine is being used. Avg lit by itself only during "Recall Avg" operation.
21	SFT annunciator	Indicates that the keyboard is in the SHIFT mode.
22	MAX annunciator	Indicates that the display is presenting the value of the highest measurement made during a min-average-maximum function. The min avg max are all lit when MAM routine is being used. Max lit by itself only during "Recall Max" operation.
23	AC REF annunciator	Indicates that the instrument is using an external AC reference voltage.
24	DC REF annunciator	Indicates that the instrument is using an external DC reference voltage.
25	SRQ annunciator	Indicates that the instrument is transmitting a service request (interrupt) to the controller in system operation.
26	LIS annunciator	Indicates that the instrument has been programmed by the controller to function as a listener on the General Purpose Interface Bus.
27	REM annunciator	Indicates that the instrument has been put into the remote operating mode by the controller (parallel BCD or GPIB) or by the operator via the keyboard (parallel BCD only).
28	TLK annunciator	Indicates that the instrument has been programmed by the controller to function as a talker on the General Purpose Interface Bus.

Table 3.1 - Front Panel Controls, Indicators and Connectors continued

Reference	Item/Position	Function
29	RI annunciator	Indicates that the instrument is in the rear input mode.
30	COMMON-GUARD switch	When set to the lower position this switch connects the input common to the guard terminal.
31	INPUT high connector	Serves as the front panel connection for DC volts, AC volts, millivolts and 2-wire resistance measurements.
32	2 WIRE/4 WIRE switch	This switch controls the front panel inputs only. When set to the 2 wire position this switch connects the ohms source terminals to the input terminals to facilitate convenient 2 wire resistance measurements. When set to the 4 wire position, the ohms source terminals are disconnected from the input terminals. When used in the 4 wire position the instrument must be connected to the unknown resistance via 4 input connection leads. This switch should be in the 4-wire position when measuring High Voltage AC or DC (> 500V). The 2-wire/4-wire Operation is explained in paragraph 3.3.6, page 3-13.
33	OHMS SOURCE connector	Provides the output source current for resistance measurement.
34	OHMS SOURCE low connector	Provides the source current for resistance measurements.
35	INPUT low connector	Provides the front panel input connection for AC volts, DC volts, millivolts and ohms 2-wire resistance measurements.
36	GUARD connector	Provides the front panel connection for the guard plane of the instrument.
37	Keyboard	Provides operate control of all instrument functions in local mode. Functions of the individual pushbuttons on the keyboard are described in Table 2.
38	PWR switch/indicator	Lights the switch and applies main AC line power to the instrument when set to the ON position. Causes the DMM to perform the following Initialization Sequence: a. Performs Auto-Test/Auto-Cal. b. Sets DMM to Internal Reference, DC Volts, Auto-range and Continuous Readings.

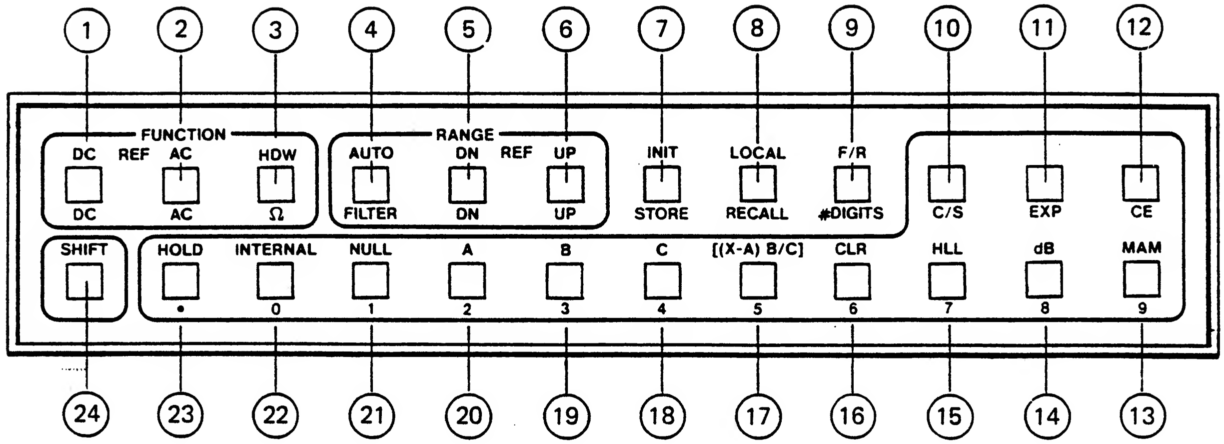


Figure 3.1A - Keyboard Control Layout

Table 3.2 - Keyboard Control Functions

Reference	Control	Function
1	DC	Selects the DC volts/millivolts function and puts the instrument in AUTO range.
	SHIFT DC	Selects the Software Ratio function, DC reference (applied to deselected input).
2	AC	Selects the AC volts function and puts the instrument in AUTO range. Requires Option 10 or Option 14.
	SHIFT AC	Selects the Software Ratio function, AC reference (applied to deselected input). Requires Option 10 or Option 14.
1	SHIFT HDW DC	Selects DC external reference voltage at EXT REF terminals and 4-wire DC ratio mode (Option 34) for hardware ratio measurements.
2	SHIFT HDW AC	Selects AC external reference voltage at EXT REF terminals. (Requires Option 11 for hardware ratio measurements.)
1 2	SHIFT HDW THEN DC AC SIMULTANEOUSLY	Prepares instrument for external reference selection. Pressing both keys simultaneously selects DC coupled AC external reference voltage at EXT REF terminals (Option 11) for hardware ratio measurements.
1 2	SIMULTANEOUSLY DC AC	Pressing both keys simultaneously selects DC coupled AC when True RMS Converter (Option 10) is installed.
3	Ω	Selects the resistance function and puts the instrument in AUTO range. (Requires Option 24.)
4	FILTER	Toggles the 4-pole active filter (on, off, on, etc.).
	SHIFT AUTO	Toggles the AUTO range function (on, off, on, etc.).
5	SHIFT DN	Causes the reference voltage range to down-range on each depression and causes the instrument to display the range of the reference voltage on the range annunciators for as long as the key is held down.
	DN	Takes the instrument out of AUTO range (if in auto) on first depression. Each subsequent depression causes the instrument to down-range.

Table 3.2 - Keyboard Control Functions continued

Reference	Control	Function
6	SHIFT UP	Causes the reference voltage range to up-range on each depression and causes the instrument to display the range of the reference voltage on the range annunciators for as long as the button is held down.
	UP	Takes the instrument out of AUTO range (if in auto) on first depression. Each subsequent depression causes the instrument to up-range.
7	SHIFT INIT	Takes the instrument out of high level function modes and returns it to internal reference.
	STORE (X)	Causes the instrument to store the previous reading or the value shown on the display into the location determined by the operator. Storage location selection is accomplished by depressing one of the keys: A B C dB HLL (*)
8	SHIFT LOCAL	Sends an RTL (return to local) request to the systems interface. Returns the instrument to local operation unless the instrument has been given a local lockout (LLO) command. Holding the button down causes the instrument to display the GPIB device address on the readout.
	RECALL (X)	Causes the instrument to recall and display the present value stored in anyone of the following locations: A B C dB NULL MAM HLL (*)
9	SHIFT F/R	Toggles the front/rear relay so that either input may be used for measurement. When the rear input is in use the RI indicator on the front panel is lit (reference 29, table 3-1).
	#DIGITS 4 5 6	Selects the display length, integration time and causes the instrument to perform an Auto-Test/Auto-Cal routine. After depressing the number of digits pushbutton the 4, 5 or 6 button must be depressed to select the number of digits.
9	#DIGITS 0	Disables Auto-Test/Auto-Cal until SHIFT/INIT is pressed.
9	#DIGITS 3	Causes the output of the Fast A/D converter to be displayed in signed octal.
10	C/S	The "change sign" pushbutton reverses the polarity of entered mantissas and exponents.
11	EXP	Enables the entry of exponents. The depression of this key signals the instrument that numbers to follow are to be stored as exponents.
12	CE	"Clear Entry Key" clears the numbers in display and returns the machine to its previous state.

*Reference HLL operating procedure (page 3.16)

Table 3.2 - Keyboard Control Functions continued

Reference	Control	Function
13	SHIFT MAM	Toggles the MAM function. MIN, AVG and MAX annunciators are lit while the MAM function is selected.
	9	Enters the digit 9 which will then be displayed until it is assigned a memory location.
14	SHIFT dB	Toggles the dB function. This function displays the measurement value in decimals referenced to 1 milliwatt in 600 ohms. (The resistance value may be changed to any desired value; see the Decibel operating procedure (page 3.21).
	8	Enters the digit 8 which will then be displayed until it is assigned a storage location.
15	SHIFT HLL	Toggles the HLL function. See the hi/low limit operating procedure.
	7	Enters the digit 7 which will then be displayed until it is assigned a memory location.
16	SHIFT CLR	Causes the selected storage register to be set to a value which least affects the display as follows: SHIFT CLR [(X-A) B/C] — Sets A to 0, B and C to 1.0 SHIFT CLR A — Sets A to 0, B and C unaffected SHIFT CLR B — Sets B to 1.0, A and C unaffected SHIFT CLR C — Sets C to 1.0, A and B unaffected SHIFT CLR MAM — Clears the min, max and average SHIFT CLR dB — Sets R to 600 ohms (0 dB = 1 mW into 600Ω)
	6	Enters the digit 6 which will then be displayed until it is assigned a memory location.
17	SHIFT [(X-A) B/C]	Causes the instrument to perform the mathematical formula indicated above the key. X is the present measurement value (reference Figure 3.9). When selected, the constant stored in memory location A is subtracted from the present measurement value. The difference is then multiplied by the constant stored in memory location B and divided by the constant stored in memory location C. The values of A, B and C must have been entered prior to using the math function. The function may be exited by again pressing SHIFT [(X A) B/C]. The constants will remain in memory until they are cleared or changed.
	5	Enters the digit 5 which will then be displayed until it is assigned a memory location.

Table 3.2 - Keyboard Control Functions continued

Reference	Control	Function
(18)	SHIFT C	Used with the store and recall keys for entering or recalling values in the storage location C.
	4	Enters the digit 4 which will then be displayed until it is assigned a memory location.
(19)	SHIFT B	Used with the store and recall keys for entering or recalling values in the storage location B.
	3	Enters the digit 3 which will then be displayed until it is assigned a memory location.
(20)	SHIFT A	Used with the store and recall keys for entering or recalling values in the storage location A.
	2	Enters the digit 2 which will then be displayed until it is assigned a memory location.
(21)	SHIFT NULL	Causes the instrument to store the present measurement value for subtraction from all future readings and begins the null function. When the null function is in use the MTH annunciator is lit. Depressing the recall button and the null button will cause the instrument to display the values stored in the null constant storage location. Note: When the null function is activated, the 6000 should not be down-ranged below the voltage range in which the null function was originally activated. Note: If filter is to be used on 10mV range (Option 41), it must be enabled prior to setting NULL. The function may be exited by again pressing SHIFT NULL. The constant will remain in memory until it is cleared or changed.
	1	Enters the digit 1 which will then be displayed until it is assigned a memory location.
(22)	SHIFT INTERNAL	Enables the internal trigger of the instrument. This pushbutton is used to take the instrument out of the hold mode.
	0	Enters the digit 0 which will then be displayed until it is assigned a memory location.
(23)	SHIFT HOLD	Places the instrument in the "hold" mode (no internal trigger) and calls for a single measurement to be made and displayed.
	•	Enters the decimal character which will then be displayed until it is assigned a memory location.
(24)	SHIFT	Toggles the keyboard shift. When in the shift mode the SFT annunciator is lit and the instrument interprets keyboard depression according to the shift (yellow colored) markings. For example, to initialize the instrument press the shift key so that the SFT annunciator lights then press the INIT/STORE key. To select the STORE function, the INIT/STORE pushbutton must be depressed while the SFT annunciator is extinguished.

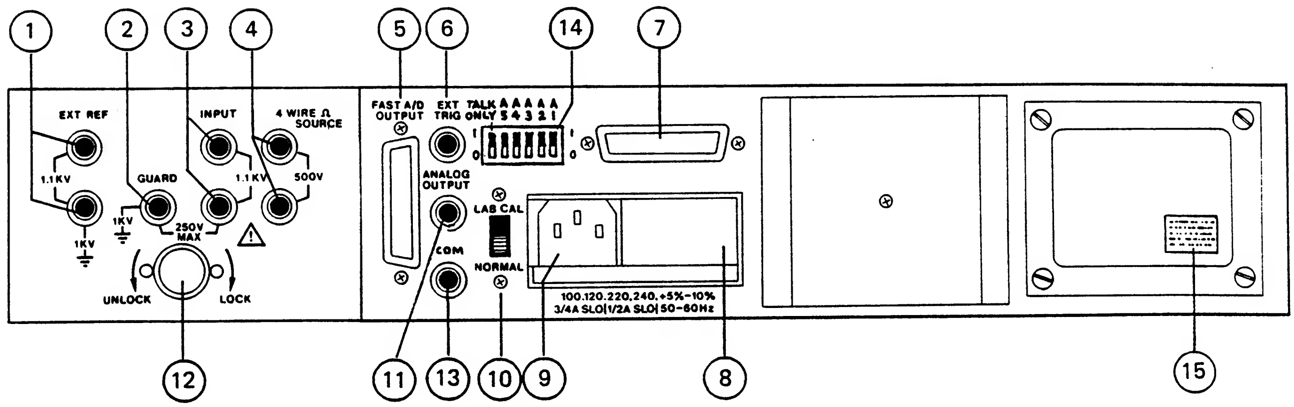


Figure 3.2 - Rear Panel Controls and Connectors

Table 3.3 - Rear Panel Controls and Connectors

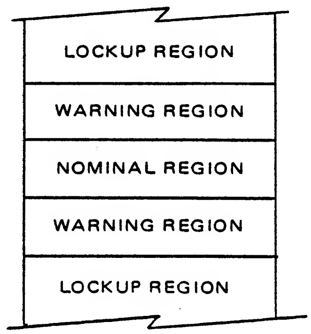
Reference	Item	Function
1	EXT REF input connectors	External reference input connectors for hardware ratio measurements.
2	GUARD connector	Provides rear panel connection for guard plane of the instrument.
3	INPUT connectors	Rear panel connection for AC volts, DC volts and 4-wire resistance measurements. Also may be used as a reference input when using automatic software ratio. For 2-wire measurements, source terminals must be connected to input terminals.
4	4 WIRE Ω SOURCE connectors	Provides the source current for 4-wire resistance measurements.
5	FAST A/D OUTPUT connector	Provides output connection for FAST A/D data if Option 03 or 03SH is installed. Provides programming input if Option 59 is installed. Pin signal assignment is presented in Section 2 of this manual.
6	EXT TRIG connector	Provides rear panel connection point for external trigger signal. (BNC connector)
7	GPIB or BCD Output connector	Provides interface bus connection. The connector is configured in accordance with IEEE 488-1975 standard digital interface if Option 55 is installed. It is the BCD output if Option 59 is installed. The pin signal assignments are presented in Section 2 of this manual.
8	Fuse holder	Fuse holder/safety interlock. Primary power fuse. Uses 3/4 amp slo blo fuse for 100-120 volt operation; 1/2 slo blo fuse for 220-240 volt operation.
9	Power connector	Connection point for primary AC power line cord.
10	LAB CAL/ NORMAL	Used for calibrating the instrument against lab standards. Not used for operation.
11	ANALOG OUTPUT connector	Provides rear panel connection of analog output signal (isolator output).
12	LOCK/UNLOCK knob	A mechanical fastener used to lock the calibration module in the instrument.
13	COM connector	Provides the low-analog output connection and serves as the Ohms Guard when the Ohms function is selected.
14	GPIB Address Switch	Allows selection of "Talk Only" mode as well as selection of DMM's GPIB address which identifies the DMM in systems operation.
15	Option Label	See paragraph 2.1.3.

3.3 BENCH OPERATION.

3.3.1 Auto Test/Auto-Cal.

3.3.1.1 When the Model 6000 is initialized by power turn on (and at predetermined intervals after turn on) the Auto Test/Auto-Cal routines are performed. The type and number of routines are determined by the particular options installed in the DMM.

3.3.1.2 Each Auto Test/Auto-Cal routine is programmed to set the circuitry to a particular configuration and then take a reading. The reading is then compared to the applicable set of four limits stored in ROM. If the reading is within the Nominal Region a correction factor will be stored in memory and the next routine will be performed.



3.3.1.3 Readings which fall in one of the two Warning Regions will cause the DMM to momentarily display an error message before proceeding to the next routine. The temporary error message indicates that a larger than normal correction factor was required to bring the DMM readings within tolerance. The message is also an indication that the instrument should be scheduled for maintenance in the near future. Reference Table 3.7 for error messages.

3.3.1.4 Readings which fall in one of the Lockup Regions will cause the DMM to stop the Auto Test/Auto-Cal routines and display an error message. The error message and lockup condition indicate that the DMM should be scheduled for immediate maintenance because it cannot self correct to required tolerances. The lockup condition may be bypassed (for troubleshooting purposes) by pressing any key on the keyboard. Reference Table 3.7 for error messages.

3.3.1.5 If the Model 6000 is equipped with a GPIB (Option 55), any Auto Test/Auto-Cal related error message will cause an SRQ to be sent to the controller. A bit will also be set in the serial poll status byte (reference Figure 3.12). A lockup condition will also cause the GPIB to refuse acceptance of program codes. The GPIB will, however, still be able to output the serial poll status byte.

3.3.1.6 DC CAL.

3.3.1.6.1 The standard DMM will perform seven DC Cal routines (DC Cal 1 through DC Cal 7). If a Preamplifier (Option 41) is installed, the instrument will also perform the DC Cal 8 routine.

3.3.1.7 OHMS CAL.

3.3.1.7.1 The Model 6000 will perform five Ohms Cal routines (Ohms Cal 1 through Ohms Cal 5) when the Ohms board (Option 24) is installed. If a Preamplifier (Option 41) is also installed, the instrument will also perform the Ohms Cal 6 routine.

3.3.2 Range Control.

3.3.2.1 Upon initialization the instrument goes to its home state; autorange, DC volts and the range is set to whatever the instrument sees at the input terminals. For example, if a 1.5 volt battery is connected to the input terminal and the instrument is initialized by power turn on, the instrument will turn on, go through Auto-Cal routines and initialize in the home state (autorange, DC volts, 1 volt range).

3.3.2.2 To change the range manually depress the up or down keyboard buttons once to take the instrument out of autorange. This extinguishes the auto annunciator and the instrument will now respond to depression of the up or down keyboard buttons changing the range one increment for each depression.

3.3.2.3 To illustrate the manual range control sequence short the input terminals and apply power to the instrument. Note that it initializes in autorange on the 100 millivolt range. The instrument initializes to the range appropriate for the voltage it sees at the input terminals but it does not autorange down to the 10 millivolt range. Depressing the UP key once will extinguish the AUTO annunciator and put the instrument in manual range control mode. The next depression of the up pushbutton switches the instrument to the 1 volt range and each successive depression causes the

instrument to progress to the 10, 100 and the 1000 volt DC range. The instrument can be manually down ranged by depression of the down pushbutton. Each successive depression will cause the instrument to progress to the 100, 10, 1 and the 100 millivolt range. If the Millivolt DC Option (41) is installed the instrument may be manually downranged to the 10 millivolt range provided the input is less than 22 millivolts. If the input signal is over the 10 millivolt range the instrument will automatically uprange to the 100 mV range.

3.3.2.4 The instrument will go into autorange as a result of only 4 possible operations: 1) power on initialization, 2) manual depression of the SHIFT AUTO keyboard pushbuttons, 3) transmission of the autorange command by the controller in system operation and 4) a manual function change.

3.3.3 Autorange.

3.3.3.1 In the autorange mode except for the 10 millivolt DC and 1 ohm ranges, the instrument automatically changes its ranges as the measurement signal is increased above 160% of range. For example, when the instrument is on the DC 1 volt range in the autorange mode as the measurement voltage increases to approximately 1.6 volts the instrument will automatically switch to the 10 volt range. Conversely, as the voltage is decreased to approximately 0.9 volts the instrument will automatically downrange again to the 1 volt DC range. In the 10 millivolt and 1 ohm ranges the instrument automatically upranges at 220% of range. For best results, the DMM should be placed in manual ranging when switching inputs greater than 500 VDC.

3.3.4 DC Volts Measurement.

3.3.4.1 The Model 6000 basic instrument is capable of measuring DC volts in 5 ranges: 100 mV, 1V, 10V, 100V and 1000V. A 10 mV range is also available when the instrument is equipped with a Preamplifier (Option 41). To measure DC voltage proceed as follows:

1. Connect the instrument to the primary AC power source, turn the power switch on and allow it to initialize. Verify that the instrument initializes to the home state: DC volts function and AUTO range.

2. Set 2-wire/4-wire switch to 4-wire position if measuring voltages above 500V.

3. Connect the measurement voltage to the INPUT terminals and read the measurement value from the display and range annunciators.

3.3.5 AC Volts Measurement.

3.3.5.1 The Model 6000 instrument is capable of measuring AC RMS volts in 4 ranges: 1V, 10V, 100V and 1000V when equipped with either AC Option 10 (True RMS) or Option 14 (Averaging) AC converters. To measure AC voltage proceed as follows:

1. Connect the instrument to the primary AC power source, turn the power switch on and allow it to initialize. Verify that the instrument initializes to the home state: DC volts function and AUTO range.

2. Set 2-wire/4-wire switch to 4-wire position if measuring voltages above 500V.

3. Select the AC volts function by pressing the AC key and verify that the AC annunciator lites.

4. Connect the measurement voltage to the INPUT terminals and read the measurement value from the display and range annunciators.

NOTE

If the True RMS Option is installed the instrument can measure AC, DC or a signal composed of a DC voltage containing an AC component. To measure a signal containing both AC and DC components "DC coupled AC" mode must be selected.

3.3.5.2 To select DC coupled AC mode press the DC and AC keys simultaneously and verify that both the DC and AC annunciators come on.

3.3.6 Resistance Measurement.

3.3.6.1 The basic Model 6000 instrument is capable of measuring resistance in 8 ranges: 10Ω, 100Ω, 1KΩ, 10KΩ, 100KΩ, 1MΩ, 10MΩ and 100MΩ. A ninth range (1Ω) is available with the addition of Option 41.

3.3.6.2 OHMS GUARD

3.3.6.2.1 One of the features of the Model 6000 is the Ohms Guard which eliminates errors due to shunt leakage effects during high resistance measurements and allows certain in-circuit resistance measurements to be made with full accuracy. Use of the Ohms Guard during high resistance measurements is described in Paragraph 3.3.6.3. In-circuit resistance measurements are described in Paragraph 3.3.6.2.2.

3.3.6.2.2 Using the Ohms Guard during measurement of resistor networks eliminates the need to disassemble the network to determine individual resistor values. On the 6000, the low ANALOG OUTPUT terminal (COM) on the rear panel serves as the Ohms Guard when OHMS is selected. A typical in-circuit resistance measurement is shown in Figure 3.3A where the desired value R_X is shunted by R_1 and R_2. Connecting the Ohms Guard to the junction of R_1 and R_2 effectively removes them from the measurement circuit, as shown in Figure 3.3B. Since neither R_1 or R_2 are in the Ohms Amplifier feedback loop, they will not seriously affect the accuracy of the measure-

ment. R_1 and R_2 may have any value above the minimum values listed below:

R_1 minimum value = 20% of Range F.S. (5000Ω min.)

R_2 minimum value = 5000Ω

R_1's minimum value is limited by error produced by the ohms amplifier's offset voltage. R_2's minimum value is limited by the maximum output current available from the ohms amplifier.

3.3.6.3 To measure resistance proceed as follows:

1. Connect the instrument to the primary AC power source, turn the power switch on and allow it to initialize. Verify that the instrument initializes to the home state: DC volts function and AUTO range.

2. Select the resistance function by pressing the Ω push-button and verify that one of the Ω annunciators (Ω, KΩ or MΩ) lites.

3. TWO-WIRE MEASUREMENTS.

   a. Connections for a simple two-wire shielded ohms measurement are shown in Figure 3.4. It consists simply of a single-conductor shielded cable with the conductor serving as both the + Ω SOURCE and + INPUT leads and the shield carrying – Ω SOURCE and – INPUT. If front panel terminals are used, connections between + INPUT and + Ω SOURCE, and – INPUT and – Ω SOURCE can be made by setting the 2-WIRE/4-WIRE Switch to the 2-WIRE position. While reasonably accurate measurements can be made with this method, shunt leakage problems result from the parallel combinations of R_X and the cable impedance. This causes loss of accuracy, especially at high resistance (100 MΩ range). Also, lead resistance becomes a factor in the 1, 10 and 100 ohms ranges; the four wire measurement system is recommended for these ranges.

   b. A more accurate two-wire measurement connection is shown in Figure 3.4b. The + INPUT and +Ω SOURCE, – INPUT and – Ω SOURCE terminals are again tied together. But now, the positive side is a single-conductor, shielded cable with the shield tied to Ohms Guard. Ohms Guard is the low ANALOG OUTPUT terminal on the rear panel of the Model 6000 when ohms is selected. The negative side is a single wire connected as shown. Guard current is present in the low side, but the leakage problems of the first configuration are eliminated.

   c. In high noise-level environments, the configuration shown in Figure 3.4c is recommended. This method also eliminates error due to shunt leakage, but provides more complete shielding. The positive terminals are tied together and carried in a single-conductor, double-shielded cable with the inner shield tied to Ohms Guard (– ANALOG OUTPUT). The outer shield is tied to GUARD. The negative terminals are tied together and carried in a single-conductor shielded cable with the shield tied to GUARD. This configuration eliminates guard current sensitivity, thereby increasing guarding characteristics.

4. FOUR-WIRE MEASUREMENTS.

   a. In most system applications, the device to be measured is located at a remote location requiring interconnection by cables of lengths from several to possibly hundreds of feet. When measuring low resistance values over long cables, most lead resistance problems can be solved by the use of a four-wire measurement system. If front panel terminals are used, set the 2-WIRE/4-WIRE Switch to 4-WIRE position.

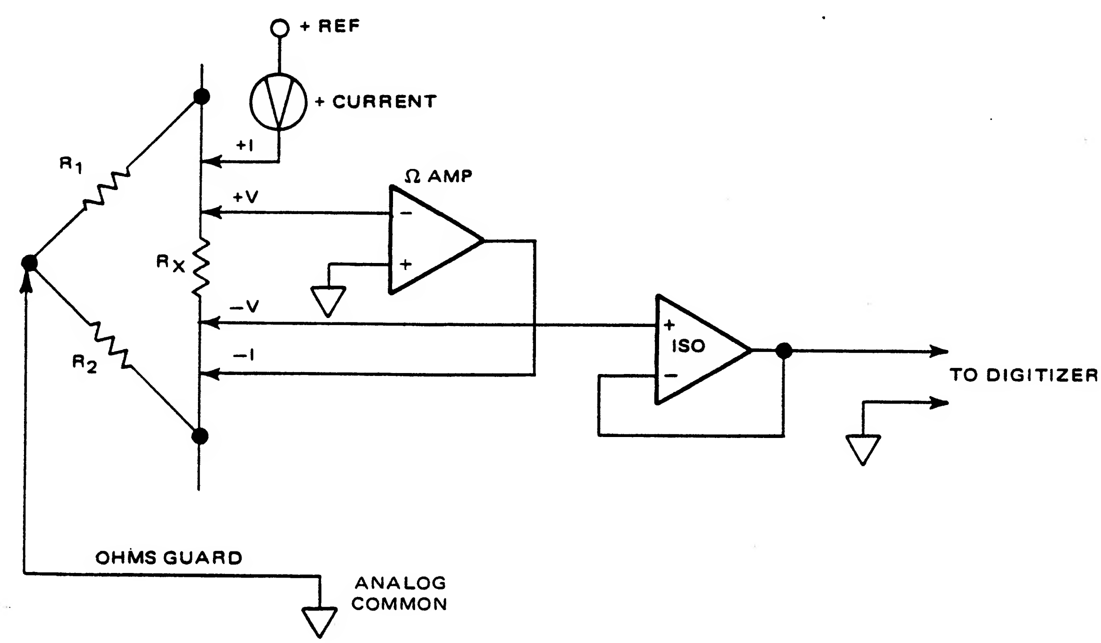
   b. For high resistance measurements over long cables, other problems are encountered: noise pick-up, leakage resistance, and capacitive loading of the system. These problems can be minimized by proper shielding and the use of ohms guard.

   c. Figure 3.5a shows a basic shielded four-wire ohms measurement configuration. This method uses two single-conductor shielded teflon cables. The conductors carry the positive sides of the INPUT and CURRENT lines while each shield carries the low side.

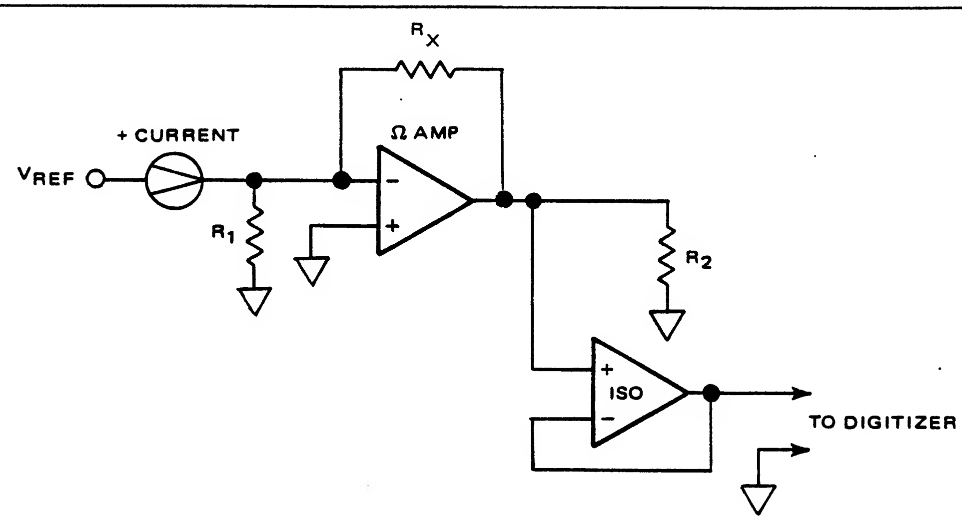
   d. This configuration, although shielded, places the shield capacitance and cable leakage in parallel with R_X. This results in loss of accuracy and slow measurements. In addition, it is very responsive to the triboelectric effect at high resistance measurements.

   e. Better guarding is achieved by the use of the configuration shown in Figure 3.5b. Here again, RG196U teflon dielectric cable (either single-conductor shielded or two-conductor shielded) is used on the positive terminals. The shield(s) are connected to Ohms Guard (low ANALOG OUTPUT terminal). The negative leads are single wires with the – INPUT terminal tied to GUARD.

   f. This eliminates much of the shunt leakage problem of the previous configuration since guard current now flows through the low side of the measurement circuit. Measurement is much faster since the shield capacity is driven by the guard current.



A - Complete Circuit



B - Simplified Circuit

Figure 3.3 - In-Circuit Resistance Measurement

g. A high-noise environment calls for the "super" configuration shown in Figure 3.5c. Here, a two-conductor, double-shielded cable is used as the positive leads. The inner shield is tied to Ohms Guard. A two-conductor shielded cable is used as the negative leads. Its shield is tied to GUARD and to the outer shield of the positive cable. The shield is also tied to – Ω SOURCE at the measurement point. This configuration maintains high guarding characteristics while eliminating guard current sensitivity.

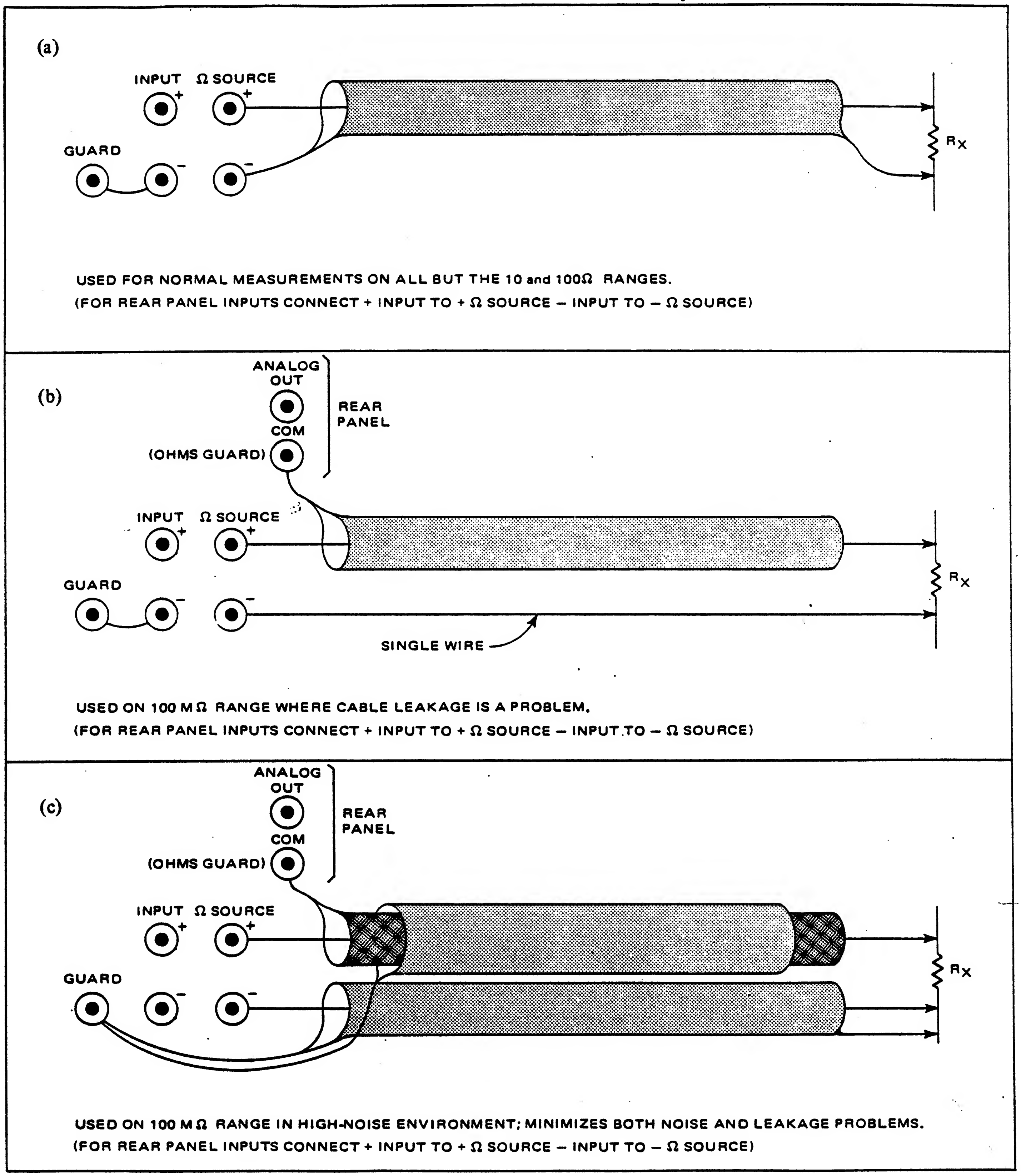


Figure 3.4 - Two Wire Ohms Measurements

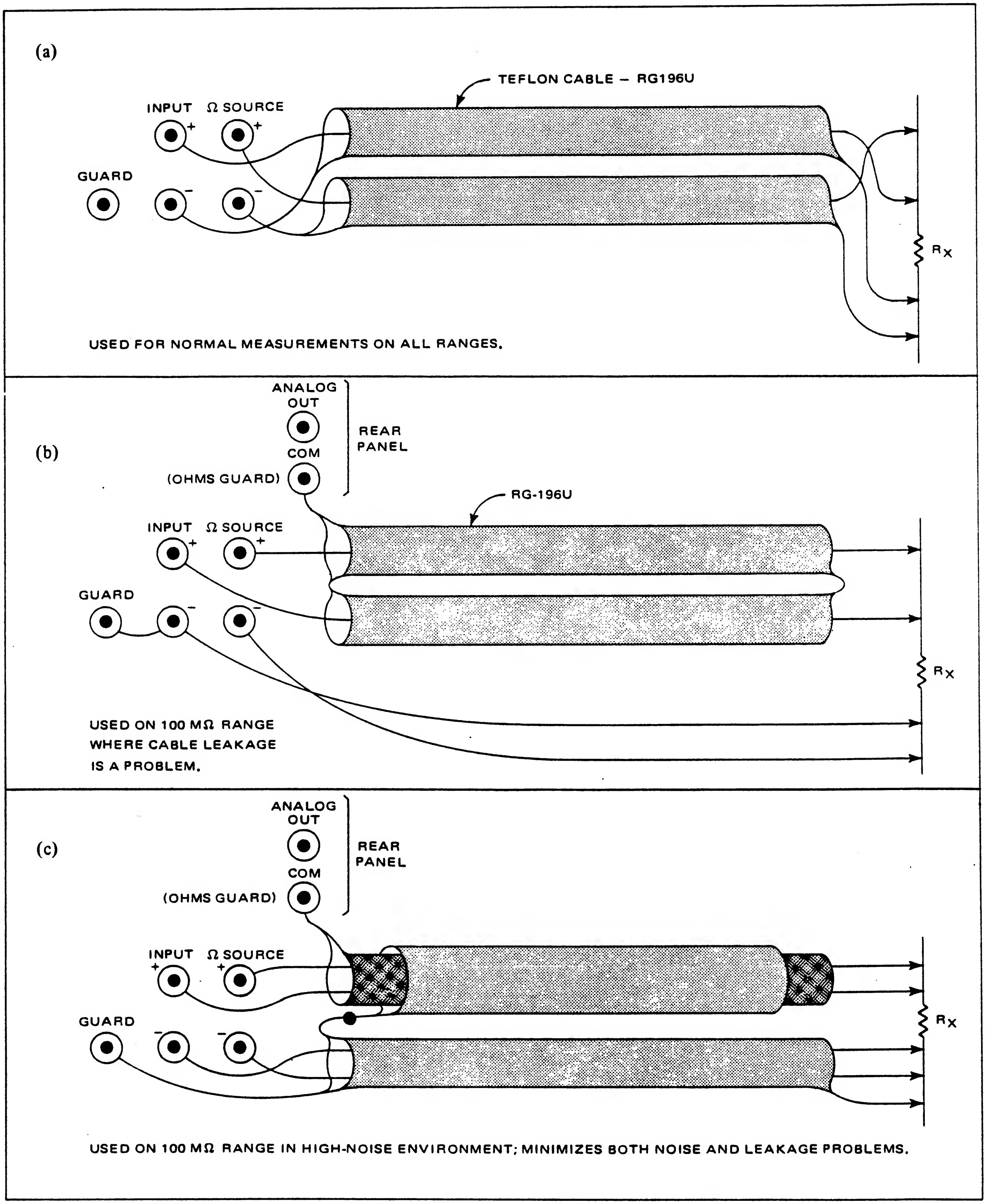


Figure 3.5 - Four Wire Ohms Measurement

5. If measuring on 1Ω range, disconnect the +I (+ current) lead at the Voltmeter terminal. Wait until the display value is stable within ± 5 digits and press NULL key. Reconnect the +I lead and read the value from the display. Extreme care must be exercised to avoid generating thermal voltages between connection points. Use cables with Kelvin clips, or other low thermal terminations at resistor connection points.

6. Read the measurement value from the display and range annunciators.

3.3.7 High-Low-Limit Operation.

3.3.7.1 The high-low-limit (HLL) function provides two basic modes of operation. The first mode is the one or two limit, two or three category mode which compares the measurement with preprogrammed limits entered by the operator. The second HLL mode is the three to five limit, four to seven category mode. In this mode the operator enters between three and five limits and the instrument will then compare the input measurement with these limits and categorize the input into four to seven categories.

3.3.7.2 SINGLE OR DUAL LIMIT.

3.3.7.2.1 This is the simplest mode of HLL operation. In this mode the operator enters an upper and lower limit into memory and selects HLL operation mode. The instrument then compares each measurement to the lower and upper limit and presents the message Lo, Pass or Hi on the front panel display.

3.3.7.2.2 For example, if the operator wanted to verify that a voltage falls between 4 and 5 volts DC, he simply enters 4 as the lower limit (HLL-1) and 5 as the upper limit (HLL-2); once the HLL mode is selected any measurement falling below 4 volts will cause the display to present the message Lo, any measurement voltage between 4 and 5 volts will cause the display to present the message PASS, while any measurement voltage above 5 volts causes the display to present the message HI as shown in Figure 3.6.

3.3.7.2.3 If it is desired to set only one boundary limit, the instrument will present only two messages. For example, to determine whether a measurement is higher than a predetermined minimum the limit is entered in limit location 1 and for measurements falling under the limit the instrument will display the message Lo. For a measurement above the limit the instrument will display the PASS message. Similarly if the single limit is entered in location 2 the instrument will display the PASS or HI messages.

3.3.7.2.4 At this time it should be pointed out that the HLL mode is useable with AC volts, DC volts, resistance and ratio measurements. Further, the operator may set the parameters for limits as tightly or as broadly as desired. The pass category may be set so that the lower limit and upper limit are only a few microvolts apart. On the other hand, the lower and upper limits may be set hundreds of volts apart, depending on the requirements of the measurement application.

MEASUREMENT VALUE	HLL DISPLAY				
<4V	L	o	.	.	
4-5V	P	A	S.	S.	
>5V			.	H.	I

Figure 3.6 - LO-PASS-HI Displays

3.3.7.2.5 The measurement value or ratio value (defined as X) may be part of the mathematical function (X-Null) - (A x B ÷ C). In this case, the scaled values of X will be tested against the HLL limits.

3.3.7.2.6 When using the HLL function with single or dual limits remember the following:

1. The key sequence SHIFT, CLR, HLL should be executed prior to storing limits. This procedure sets all limits to their power-on values and enables the Lo-PASS-HI display mode.

2. If the Lo-PASS-HI display mode is desired, HLL-1 and HLL-2 should be used for storage of limits. Do NOT store limits using HLL-3 to 6, otherwise the 7-bin sort display will appear.

3.3.7.3 SEVEN BIN SORT OPERATION.

3.3.7.3.1 The multiple category HLL operation is selected automatically whenever the operator enters more than 2 limit parameters. In the multiple category HLL mode the instrument can present up to 7 display messages as shown below.

LIMIT MEMORY LOCATIONS	5	3	1	2	4	6	
DISPLAY CATEGORIES	Lo . .	c . .	b . .	. A .	. . b	. . c	. . HI
LIMITS (VOLTS OR OHMS)	2	3	4	5	6	7	

MEASUREMENT VALUE	HLL DISPLAY				
<2V	L	o	.	.	
2-3V	c		.	.	
3-4V		b	.	.	
4-5V			A .	.	
5-6V			.	b .	
6-7V			.	.	c
>7V			.	H .	I

Figure 3.7 - Seven Bin Sort Display Examples

3.3.7.3.2 To illustrate the application of this measurement sorting function, referred to as HLL, assume that it is desired to fit measurements into the seven categories shown by the limits in Figure 3.6. The limits could be applicable to AC or DC voltages or to resistance values in ohms. For the sake of discussion assume that the limits shown in the illustration represent DC voltage limits. Note that the "A" category falls between the 4 and the 5 volts. This is common TTL logic voltage. Note also that the other six categories fall between 1 volt steps. Note also that the voltage limits selected increase in voltage from left to right. It is absolutely essential that limits be entered into limit locations in ascending values with the more negative or lower value on the left and the more positive or higher value on the right.

3.3.7.3.3 To make the limit locations easier for an operator to memorize the storage locations have been numbered as shown; the centered limit A is bracketed by limit locations 1 and 2. The neighboring lower and higher limit locations are bracketed on the left by the odd numbers 3 and 5 and on the right by the even numbers 4 and 6. In the example shown all voltages are entered as positive voltages between 2 and 7 volts. Note that the center voltage category "A" is between 4 and 5 volts while the next lower category is between 3 and 4 volts. With limits entered into locations as shown the instrument will display the message LO for any voltage less than 2 volts and the message HI for voltage higher than 7 volts. Measurement voltages falling between 2 and 6 volts will be displayed as upper case A, lower case b or c. Figure 3.7 illustrates the display presented for the measurement inputs shown. Note that there are two lower case b categories and two lower case c categories. These may be distinguished from one another by their location on the display relative to the two flashing decimals adjacent to the category A display location.

3.3.7.3.4 Table 3.4 presents a step-by-step operating sequence demonstrating operation of the Series 6000 DMM in the HLL mode.

3.3.8 Minimum-Average-Maximum.

3.3.8.1 The Series 6000 DMM provides a minimum-average-maximum (MAM) measurement capability. When used in this mode the instrument performs the following operations: a) stores the least positive (or most negative) value measured during the MAM operating cycle, b) stores the value of the most positive (or least negative) measurement made during the MAM cycle, c) calculates the average value of all measurements taken during the MAM cycle, d) counts the number of total measurements made during the MAM measurement cycle.

3.3.8.2 To accomplish this function, the instrument makes the first measurement and stores it. It then compares each successive reading with the previous measurement to determine whether the present reading is higher or lower than the previous reading. If the second reading is lower than the first, the instrument will store the present reading in the Min memory location. The instrument will also perform an arithmatic average on the two readings and store the result in the Avg memory location. The machine then makes a new measurement, performs the comparison again and, if the new measurement is higher or lower than a previous reading it is stored in the Min or Max memory location. The instrument uses a fourth memory location to store the count of the number of measurements made during the MAM measurement cycle.

3.3.8.3 In a typical application, the instrument may be connected to another device or system and used to monitor a power supply voltage or the AC line voltage over a period of time. The operator can leave the instrument unattended and return at a later time and recall the minimum voltage level the average of all measurements made, the maximum voltage level and the total number of measurements made. Table 3.5 presents a step-by-step operating procedure for using the 6000 in the MAM mode.

NOTE

The MAM function will update the minimum and maximum readings indefinitely, but will not update the average or the number of measurements readings beyond the first 10,000 samples.

Table 3.4 - Example of HLL Operating Procedure

Step	Equipment Connection	Control or Key	Display and Annunciators	Function or Interpretation
1	AC Power			
2		POWER ON	Initialization Sequence - See Table 3.1, Reference 38	
3	4.5 VDC to Input		4.5XXX DC 10 AUTO	Display indicates input voltage
4		4	4.	Enters 4 volt limit
5		STORE	4. DC 10 AUTO SFT	Instructs instrument to store value on display when location entered
6		HLL	HL DC 10 AUTO	Selects HLL limit storage area for storage
7		1	4.5XXX DC 10 AUTO	Selects HLL storage location 1, stores value entered (4) and returns to DC, 10, AUTO
8		5		
9		STORE	Display and annunciator sequence similar to steps 4 thru 7 except for values and storage locations	This Key entry sequence stores the limit value 5 in HLL location 2 as described in steps 4 thru 7
10		HLL		
11		2		
12		3		
13		STORE		Stores value 3 in HLL limit location 3
14		HLL		
15		3		

Table 3.4 - Example of HLL Operating Procedure continued

Step	Equipment Connection	Control or Key	Display and Annunciators	Function or Interpretation
16		6		Stores value 6 in limit location 4
17		STORE		
18		HLL		
19		4		
20		2		Stores value 2 in limit location 5
21		STORE		
22		HLL		
23		5		
24		7		Stores value 7 in limit location 6
25		STORE		
26		HLL		
27		6		
28		SHIFT	4.5XXX DC 10 AUTO SFT	Selects upper case key functions
29		HLL	.A. DC 10 AUTO HLL	Selects HLL function
30	The instrument is now ready to perform the HLL function. If the input voltage is varied the instrument will present display messages from Lo to HI as described in previous paragraphs.			
31	The function may be exited by again pressing SHIFT HLL. The constants will remain in memory until they are cleared or changed.			
32	The constants may be cleared by pressing SHIFT CLR HLL.			

Table 3.5 - Example of MIN-AVG-MAX Operating Procedure

Step	Equipment Connection	Control or Key	Display and Annunciators	Function or Interpretation
1	AC Power			
2		POWER ON	Initialization sequence - see Table 3.1, Reference 38	
3	4.5 VDC to INPUT		4.5XXX DC 10 AUTO	Display indicates input voltage
4		SHIFT	4.5XXX DC 10 AUTO SFT	Selects upper case keyboard functions
5		MAM	4.5XXX DC 10 AUTO MIN AVG MAX	Selects the Min-Avg-Max function
6	Allow the instrument to measure the input voltage for approximately one minute while varying the input voltage between approximately 4 and 5 VDC.			
7		SHIFT	4.5XXX DC 10 AUTO	Selects upper case keyboard functions
8		MAM		Toggles the instrument out of MAM function
9		RECALL MAM	4.XXX DC 10 AUTO MIN	Display indicates lowest measurement value recorded during MIN-AVG-MAX function
10		RECALL MAM	4.5XXX DC 10 AUTO AVG	Display indicates average measurement value of all measurements recorded during MIN-AVG-MAX function
11		RECALL MAM	4.XXX DC 10 AUTO MAX	Display indicates maximum measurement value recorded during MIN-AVG-MAX function
12		RECALL MAM	XXX n	Display indicates number of measurements made during MIN-AVG-MAX cycle
13	The MAM measurement values may be cleared by pressing SHIFT CLR MAM. The MAM function may be reentered without first clearing the measurement values. In this case, the present MAM values will be updated by the new readings.			
14	The MAM measurement values may be recalled, without leaving the function, by performing steps 9 thru 12. The MAM function will stop during the recall period, but it may be started again by pressing CE.			

3.3.9 Tri-Function Ratio.™

3.3.9.1 The Series 6000 can operate in three different ratio modes: Math Ratio, Automatic Software Ratio and Hardware Ratio (Option 34).

3.3.9.2 MATH RATIO.

3.3.9.3 The Math Ratio is provided as a part of the standard Series 6000, and fits the following formula:

$$R = \frac{X}{C}$$

Where: X = the measured input
C = the stored constant
R = the displayed ratio

An example of the Math Ratio key sequence is shown below.

SHIFT CLR [(X-A) B/C] ☐ ☐ ☐	Clears constants A, B and C.
☐ ☐ ☐ 6 STORE C	Stores constant "6" in memory location C.
SHIFT [(X-A) B/C] ☐ ☐	Display reading will now equal the measured input divided by 6.

3.3.9.4 SOFTWARE RATIO.

3.3.9.5 The Software Ratio is also a part of the standard DMM. The input signal and the reference signal are connected to the DMM input terminals (one signal to the front and one to the rear). Ratio mode is entered by selecting SHIFT AC (for AC reference signal) or SHIFT DC (for DC reference signal). The instrument will alternately measure the front and rear inputs and perform a ratio calculation. The relationship of the inputs in the ratio calculation is dependent upon the status of the RI (rear input) annunciator. The table shown below illustrates the signal relationships for the on-off conditions of the RI annunciator.

RI Annunciator Condition	Front Input Terminals	Rear Input Terminals	Ratio Displayed
Off	Measurement Signal	Reference Signal	Ratio = $\frac{\text{Front}}{\text{Rear}}$
On	Reference Signal	Measurement Signal	Ratio = $\frac{\text{Rear}}{\text{Front}}$

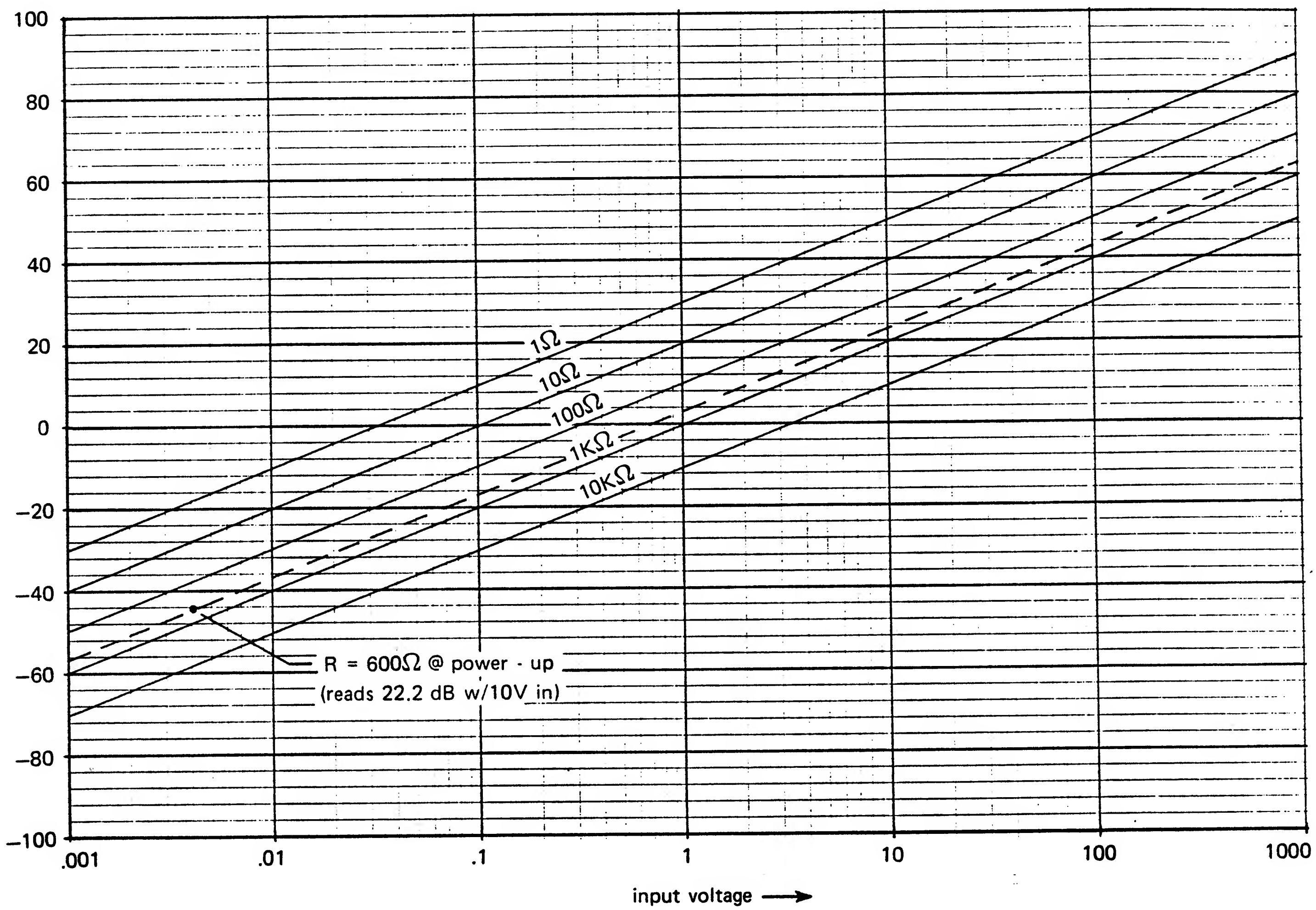
An example of the software ratio procedure is shown in Table 3.6.

Table 3.6 - Example of Software Ratio Operation

Step	Equipment Connection	Control or Key	Display and Annunciators	Function or Interpretation
1	AC Power			
2		POWER ON	Initialization Sequence - See Table 3.1, Reference 38	
3	28V DC to Front INPUT Terminals		28.XXX DC 100 AUTO	
4	7 VDC to Rear INPUT Terminals		28.XXX DC 100 AUTO	
5		SHIFT ☐ DC ☐	4 DC 100 AUTO	Display = Front Input/Rear Input
6		SHIFT ☐ F/R ☐	.25 DC 100 AUTO RI	Note: Each depression of SHIFT F/R causes the RI annunciator to go on and off. Press F/R so that RI is ON thereby selecting rear input.
7		SHIFT ☐ F/R ☐	4 DC 100 AUTO	Select Front Input (RI off).

3.3.9.6 The reference range is selectable and can be set between 1V and 1000V when the AC reference function is selected, or between .1V and 1000V when the DC reference function is selected. The reference range is selected by pressing the SHIFT UP or SHIFT DOWN keyboard buttons. While the button is held depressed, the LED range annunciators indicate the presently selected reference range.

Formula for V-dB



Internal Reference	External Reference
$\text{display} = 10 \log \left[\dfrac{\text{input power in mW}}{1 \text{ mW}} \right]$	$\text{display} = 20 \log \dfrac{V_1}{V_2}$ V_1 = signal V_2 = reference voltage

Figure 3.8 - dB vs Voltage

3.3.9.6 HARDWARE RATIO (OPTIONS 34 AND 11).

3.3.9.7 The Model 6000 is capable of performing hardware ratio measurements when equipped with Option 34 and/or Option 11. Option 34 provides for four-wire DC/DC, AC/DC and Ohms/DC ratios. Option 11 provides four ranges of AC reference input for AC/AC, AC/DC and Ohms/AC ratios. Due to hardware constraints, the 6000 will uprange or display "OL" whenever the signal becomes approximately ± 1.6 times the reference voltage.

3.3.10 Decibel (dB) Operation.

3.3.10.1 The 6000 DMM uses internal software to compute the value displayed when making dB measurements. The equation used for the dBm is: dBm = 10 Log (P1/.001) where P1 = $(\text{Voltage})^2$/Rref. The 6000 initializes with the reference resistor (Rref) set to the value of 600 ohms.

3.3.10.2 To perform dB measurements put the instrument into the dB mode by pressing the SHIFT and dB keys. Depress the F/R key as required to select the front input. Note that the display indicates dB. Apply the unknown voltage to the front panel input terminals and read the value in dB from the front panel display.

3.3.10.3 The simplest dB measurement is made by applying a signal to the front panel input terminals and displaying the voltage in terms of dB referenced to 1 millivolt expended in the standard 600 ohm resistor. Refer to Figure 3.8 (a graphic log chart of voltage vs dB). Note that the 600 ohm power value line (shown as a dotted line and marked "600 OHM POWER UP") crosses through the junction point of the 10 volt input voltage and 22 dB point on the chart. Thus the note, "reads 22.2 dB with 10 volts input".

3.3.10.4 The reference resistor value may also be programmed to values other than 600 ohms. This allows the Model 6000 to directly display dB measurements for other input impedances (eg: 50Ω, 300Ω, 1KΩ, 1MΩ). If, for example, measurements in dBV are to be made (0dBV = 1 volt into 1KΩ), then the reference resistor value may be set to 1KΩ. The table shown below illustrates the key sequence and the resultant display for this example (assume a 10 volt input).

Step	Key	Display
1	1 0 0 0	1000.
2	STORE	1000. SFT
3	dB	20.0 dB

3.3.10.5 The instrument may be used to make ratio measurements and present results in terms of decibels. For example, to measure the gain of an amplifier, connect the amplifier's input voltage to the rear panel input terminals of the Model 6000 DVM. Connect the amplifier output to the front panel input terminals of the instrument. Put the instrument in the ratio mode by pressing SHIFT and DC keys on the keyboard. The instrument will now display the ratio between the front and rear inputs in terms of decibels. If the output of the amplifier is less than the input of the amplifier the value displayed on the front panel of the Model 6000 will be preceded with the minus sign indicating a gain loss. Refer to the External Reference formula in Figure 3.8.

3.3.10.6 It should be noted that the dB function can be used in combination with other measurement functions such as the ratio measurement described above. Further the value of Rref does not affect the display result in a ratio operation because the instrument measures the ratio of the two input signals and then converts the ratio value to dB for display.

3.3.11 Math Function.

3.3.11.1 The Model 6000 includes in its repertoire a software mathematical function which provides for offset and scaling of measurement values or ratio values. The formula used is (X-A) x B ÷ C where X stands for the measurement or ratio value displayed on the front panel. When the math function is selected, the instrument performs the equation on the displayed value (ie: it subtracts the value of constant A from the measurement, multiplies this by the constant B and divides the result by the constant C). The math function may be selected by pressing the [(X-A)B/C] key on the keyboard or by sending the appropriate command to the GPIB interface (reference Table 3.12).

3.3.11.2 When the instrument initializes, the constants A, B and C are set to values calculated to have no effect on the measurement value X. Constant A is set to zero, constant B is set to 1 and constant C is set to 1. Thus, it can be seen that if the equation with these constants were performed on any value the result would be the same as the original value of X.

3.3.11.3 To store the A, B and C constant values used in the math algorithm, enter the desired value through the keyboard and then press the store key followed by the key of the desired memory location. Repeat this procedure for each of the three memory locations. If not changed, the constants will remain at their initialized values. The memory locations may be individually cleared by pressing the Shift, Clear and memory location keys.

3.3.11.4 OFFSET.

3.3.11.4.1 The math function may be used to perform simple measurement offsets. In this mode R = X–A, where R is the displayed value, X is the measured value and A is the offset constant. Since the stored constant (A) may be either positive or negative, the offset may be either added or subtracted from the measurement (X).

3.3.11.5 SCALING.

3.3.11.5.1 The math function may also be used to perform scaling operations. As an example, the math function may be used to convert the 1 mV/^{o}C output of the Racal-Dana Model T-10 Temperature Probe into Fahrenheit degrees. In this example the displayed reading would be equal to $\frac{(X-A)B}{C}$, where X is the measured value (in mV/^{o}C), A is the constant "–.017778", B is the constant "9000" and C is the constant "5". The resulting display will represent the Probe temperature reading in ^{o}F.

3.3.12 Hierarchy of Operations.

3.3.12.1 Multiple operations, if selected, will occur in the order shown in Figure 3.9.

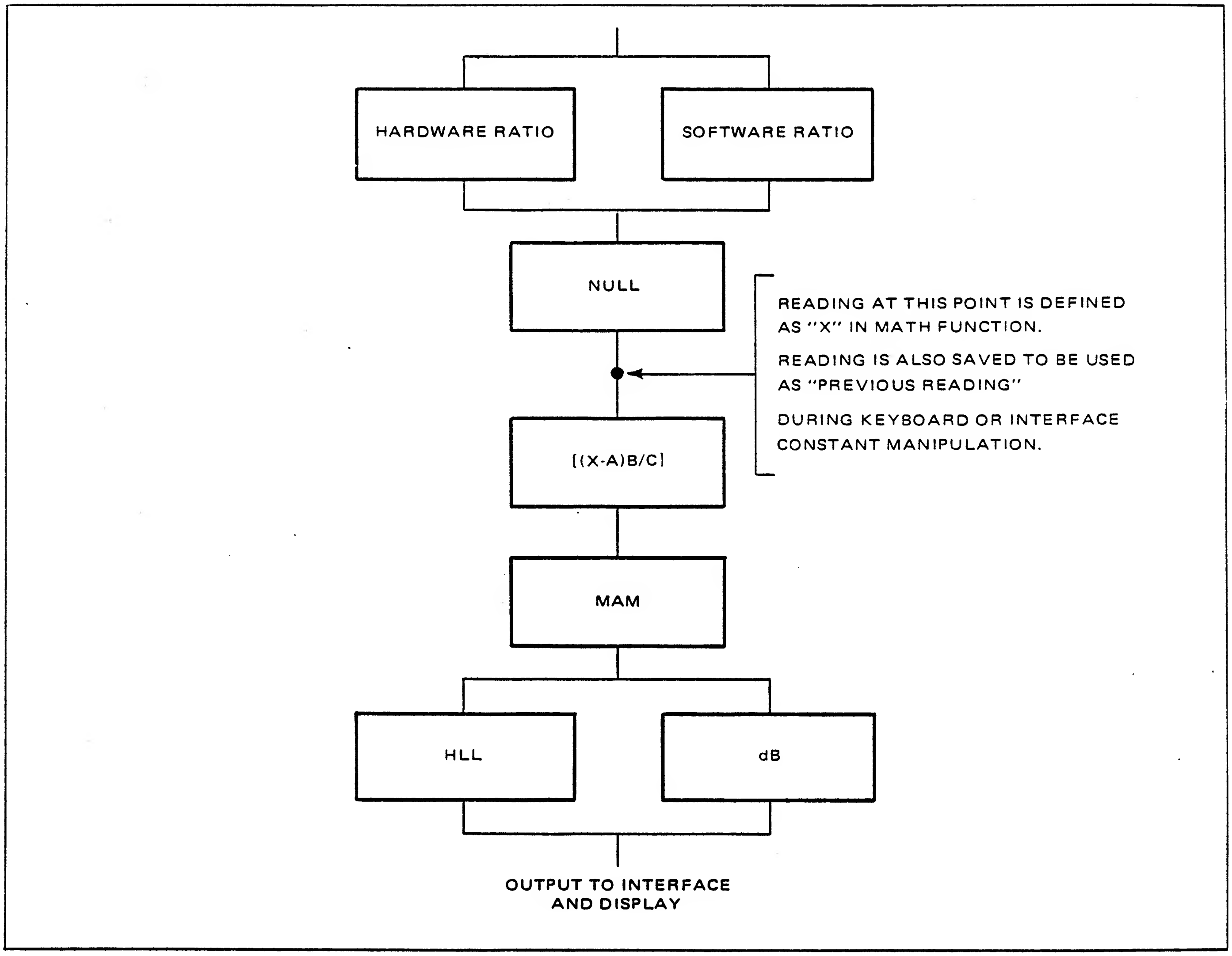


Figure 3.9 - Hierarchy of Operations

3.3.13 Error Messages.

3.3.13.1 Error messages and their descriptions are listed in Table 3.7.

Table 3.7 - Error Messages

Error Number	Description
0	Cannot calculate Log of zero
2	Attempted Auto-Cal when in 1000V signal or reference range
10	Improper Key sequence
11	Illegal #digits request
12	Divide by zero
13	Exponent cannot be displayed when in 6 1/2 digit mode
14	Display exponent beyond +9
20	Required board missing from main analog section
21	Required board missing from CAL module
22	Signal RMS converter not installed
23	Reference RMS converter not installed
24	AC converter not installed
25	Ohms converter not installed
26	4-wire DC external reference not installed
29	Fast Digitizer not installed
30	RAM failure on computer board
31	DC or reference Non Vol number out of spec
32	Ohms Non Vol number out of spec
33	Non Vol will not write or Cal switch bad
34	Clock on Non Vol board not oscillating
35	Reading will not trigger on control logic board
36	No axis crossing detected from Integrator board
	Warning Auto-Cal reading taken during:
61	DC CAL 1 (Isolator/Digitizer - Positive Ref. Voltage)
62	DC CAL 2 (Attenuator - Positive Ref. Voltage)
63	DC CAL 3 (Isolator/Digitizer - Negative Ref. Voltage)
64	DC CAL 4 (Attenuator - Negative Ref. Voltage)
65	DC CAL 5 (10 Volt Range)
66	DC CAL 6 (1 Volt Range)
67	DC CAL 7 (100 mV Range)
68	DC CAL 8 (10 mV Range)
71	OH CAL 1 (10Ω Range)
72	OH CAL 2 (100Ω, 1KΩ Ranges)
73	OH CAL 3 (10KΩ - 100MΩ Ranges)
74	OH CAL 4 (Input Bias Current)
75	OH CAL 5 (Internal 10KΩ Resistor Standard)
76	OH CAL 6 (1Ω Range)

Table 3.7 - Error Messages continued

Error Number	Description
	Unable to Auto-Cal during:
81	DC CAL 1 (Isolator/Digitizer - Positive Ref. Voltage)
82	DC CAL 2 (Attenuator - Positive Ref. Voltage)
83	DC CAL 3 (Isolator/Digitizer - Negative Ref. Voltage)
84	DC CAL 4 (Attenuator - Negative Ref. Voltage)
85	DC CAL 5 (10 Volt Range)
86	DC CAL 6 (1 Volt Range)
87	DC CAL 7 (100 mV Range)
88	DC CAL 8 (10 mV Range)
91	OH CAL 1 (10Ω Range)
92	OH CAL 2 (100Ω, 1KΩ Ranges)
93	OH CAL 3 (10KΩ - 100MΩ Ranges)
94	OH CAL 4 (Input Bias Current)
95	OH CAL 5 (Internal 10KΩ Resistor Standard)
96	OH CAL 6 (1Ω Range)

3.4 SYSTEM OPERATION.

3.4.1 This subsection presents information on the operation of the 6000 in a system. Two programmable interfaces are available. An IEEE-488 interface allows the 6000 to be connected to controllers and instruments which are manufactured by a variety of companys around the world. A parallel BCD interface is designed for those customers who are presently using the Racal-Dana Model 5900 and would like to upgrade to the 6000. In order to maximize throughput during system operation, the front panel display is given a low priority by the 6000's microprocessor. Consequently, there may be times when the 6000's seven segment display becomes incorrect or unreadable. This is no cause for concern and will not affect the accuracy of data being outputted to the interface.

3.4.2 General Purpose Interface Bus.

3.4.2.1 The Interface Board provides for remote programming of all controls and the output of data from the 6000. Inputs and outputs for the option are made via a 24 pin connector located on the rear panel. The pin location, line identification, and operation of the option are in compliance with IEEE-STD-488-1975. The Interface Board provides interface capability with other instruments and with a controller also utilizing the "interface bus" structure. Connector contact assignments are shown in Figure 3.10. The IEEE-488-1975 subsets available in the Series 6000 are listed in Table 3.8.

3.4.2.2 By assigning a unique address to the 6000, it can be "called up" by the controller or another device on the bus without interfering with other units on the bus. Switches located on the rear panel of the 6000 permit the programming of the instrument address. The coding used for the address on the option board is ASCII (hexadecimal). Any one of 31 codes can be used for the address of an instrument, but a total of 15 is the maximum number of devices that can be used on one bus. The 6000 address can be displayed by first pressing the "Shift" key and then holding the "Local" key down.

3.4.3 GPIB Description.

3.4.3.1 Of the twenty-four lines available at the connector (shown in Figure 2.4) seven are grounds, one is a shield, and the remaining 16 lines are the signal lines. All of the signal lines are either input or output lines and have the following characteristics:

Logic Levels: $1 = \text{Low} = \leq .8\text{V}$ $0 = \text{Hi} = \geq 2.0\text{V}$

Input Loading: Each input ~ two TTL loads

Output: The output is capable of driving 15 interface bus loads. It consists of an open collector driver and is capable of sinking 48 mA with a maximum voltage drop of 0.4 volts. See IEEE 488 Electrical Specifications.

3.4.3.2 The signal lines, as shown in Figure 3.10, consist of three functionally separate sets: Data, Handshake and Interface.

3.4.3.3 DATA.

3.4.3.3.1 The data lines consist of lines DIO-1 through DIO-8. These lines are the lines over which data flows between all instruments on the bus in bit parallel, byte serial form.

3.4.3.4 HANDSHAKE.

3.4.3.4.1 The transfer lines consist of: DAV (data valid), NDAC (not data accepted), and NRFD (not ready for data). These lines provide communication (between the instrument that is talking and the instruments that are listening) to synchronize the flow of information across the eight data lines. These lines derive their nomenclature from their meaning in the low or one state (eg: when NRFD is low the device is Not Ready For Data).

a. DAV. Signifies that valid information is available on the data lines.

b. NRFD. Signifies that the instrument is not ready to accept information.

c. NDAC. Signifies that the information is not accepted by the acceptor.

3.4.3.5 INTERFACE.

3.4.3.5.1 The five interface lines coordinate the flow of information on the bus.

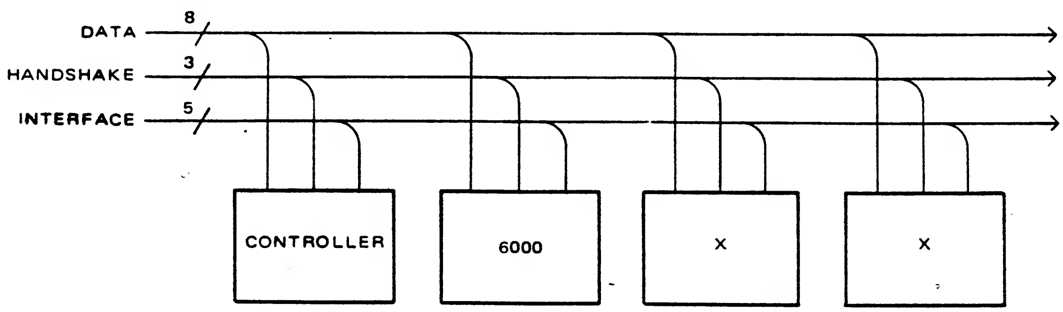
a. IFC. Places the Model 6000 in the IDLE state. (Untalk, Unlisten).

b. ATN. Indicates the nature of information on data lines during a handshake transfer sequence. Low indicates data lines carry interface commands; high indicates that the data lines carry data.

c. REN. Arms instrument to select Remote operation. (Low for Remote.)

d. SRQ. Service request signal line. Signals the controller that a peripheral or bus member wants attention for such purposes as transmitting measurement, status or condition information to the bus controller.

e. EOI. End or Identify signal. Used for two purposes: (1) to signify the end of a message and (2) to signal bus peripherals to set the I/O bit assigned for parallel poll identification process.



PIN		
1	DIO-1 Data In/Out Bit 1 (LSB)	DATA LINES ARE USED TO TRANSFER DATA FROM ONE INSTRUMENT TO ANOTHER
2	DIO-2 Data In/Out Bit 2	
3	DIO-3 Data In/Out Bit 3	
4	DIO-4 Data In/Out Bit 4	
13	DIO-5 Data In/Out Bit 5	
14	DIO-6 Data In/Out Bit 6	
15	DIO-7 Data In/Out Bit 7	
16	DIO-8 Data In/Out Bit 8	
6	DAV (DATA VALID)	HANDSHAKE LINES OPERATE IN A PROPER TIME SEQUENCE FOR COMPLETE COMMUNICATION BETWEEN INSTRUMENTS
7	NRFD (NOT READY FOR DATA)	
8	NDAC (NOT DATA ACCEPTED)	
5	EOI (END OR IDENTIFY)	INTERFACE LINES ARE USED TO PROVIDE AN ORDERLY FLOW OF INFORMATION BETWEEN UNITS
9	IFC (INTERFACE CLEAR)	
10	SRQ (SERVICE REQUEST)	
11	ATN (ATTENTION)	
17	REN (REMOTE ENABLE)	

PIN	
12	SHIELD
18	GND
19	GND
20	GND
21	GND
22	GND
23	GND
24	LOGIC GND
25	NOT USED

Figure 3.10 - Interface Signal Pin Assignments

Table 3.8 -
IEEE 488 1975 Standard Interface Subset Capability of 6000 DMM

Subset Mnemonic	Function	Capability
SH1	Source Handshake	Complete
AH1	Acceptor Handshake	Complete
T5	Talker	Complete
TE0	Extended Talker	None
L4	Listener	All except listen only
LE0	Extended Listener	None
SR1	Service Request	Complete
RL1	Remote/Local	Complete
PP0	Parallel Poll	None
DC1	Device Clear	Complete
DT1	Device Trigger	Complete
C0	Controller	None
E1	Open collector bus drivers	–

3.4.4 Handshake.

3.4.4.1 The handshake is the process by which each data byte is transferred from the source to the acceptor. Figure 3.11 illustrates the sequential relationship between the DAV, NRFD, and NDAC lines (used to transfer data bytes). Figure 3.12 illustrates the handshake flow chart.

3.4.5 Address Assignment.

3.4.5.1 When the Series 6000 is used as a system instrument it must be assigned an address as a bus member. The instrument is equipped with an address switch located on the rear panel which enables the user to assign it one of 31 decimal addresses. The decimal addresses available are the numbers 00 through 30.

3.4.5.2 Table 3.9 contains all of the information required for setting the instrument address switch and for determining the talk and listen address codes used in programming the controller.

3.4.5.3 Refer to Table 3.9 and note that the right hand column shows the decimal addresses available for assignment to the 6000. The column titled Address Switch Setting illustrates the positions of the switches for each decimal address. To set the address on the instrument at the desired decimal address, refer to Table 3.9, and set the switches on the address switch to the pattern shown in the Address Switch column of the table.

3.4.5.4 As an aid in setting the address switches, the decimal address may be displayed on the 6000 readout by first pressing the "Shift" key and then holding the "Local" key down. The address switches may then be set until the desired address appears on the display.

3.4.5.5 Once the instrument has been assigned an address, and the address switch has been set, the controller may address the instrument as a talker or as a listener by transmitting the appropriate ASCII character on the data lines. The Data Lines column shows the 7 bit binary code required for each talk and listen address assigned to the instrument. These are the codes the controller must transmit to establish the talker/listener condition of the 6000. Note that there are two address codes used for each decimal address. Each of these address codes constitutes a different ASCII character. For example, if it is desired to use the decimal address 02, the address switch on the rear panel of the instrument is set to the pattern shown in Table 3.9. As shown in the table, the talk address is the ASCII character " and the listen address is the ASCII character B. Note that the only difference in the binary code in each case is the state of data lines D6 and D7.

3.4.5.6 Table 3.9 illustrates the data line code in binary form for each decimal address. Again, using the example for decimal address 02, note that bits D1 through D5 are the same for both talk and listen address and that the only difference is in bits D6 and D7.

3.4.6 Bus Operation Sequence.

3.4.6.1 The transmission of programming instructions to the Series 6000 and the subsequent transmission of measurement data to the controller are accomplished by transmitting programming instructions as outlined in the bus operation sequence in Table 3.10. Table 3.10 and the accompanying timing chart (Figure 3.11) illustrate the sequence of the transmission of device dependent messages to the 6000 which cause it to measure the voltage of a measurement signal applied to the input and then transmit the resultant measurement data to the controller via the interface bus.

3.4.6.2 Note that the left hand column of Table 3.10 contains line numbers. These are used for reference purposes throughout the following description of the bus operation sequence. The column titled Handshake Lines indicates the high/low condition of the handshake lines at various points throughout the two-way transmission of information. In a similar fashion the columns titled Interface Lines and Data Lines contain entries reflecting the state of the interface lines and data lines during operation. The column titled Meaning or Function contains entries explaining the purpose of each operational step during the data transfer.

3.4.6.3 A timing chart is included to illustrate the condition of each individual bus line at each stage of the data transfer operation. Note that the timing chart includes numbers adjacent to each level change. These numbers refer to the individual line entries of the table.

3.4.6.4 The measurement operation used in Table 3.10 is a simple voltage measurement. The measurement parameters are as follows: Function DC volts, Range 10 volts, Trigger continuous. Note that the measurement parameters are shown in the meaning or function column of the table in lines 17 through 22 and that the program string required to perform this measurement is F1R5T1. The program string will include a carriage return and line feed, but in this case this command is automatically transmitted by the Hewlett Packard 9825.

3.4.6.5 For purposes of this example it is assumed that the Model 6000 has been assigned the decimal address 02 and that the controller is a Hewlett Packard 9825 calculator with a talk address U. It is further assumed that both the controller and the Model 6000 are system connected, turned on and operational.

3.4.6.6 Table 3.10 shows the sequence of bus operation. Lines 1 through 13 show the detailed operation of the bus for one handshake cycle (ie: the transmission of one ASCII character as a bus message). Lines 14 through 44 do not indicate the detail for each handshake cycle; they indicate only the transmission of the characters required for the programming commands and the subsequent transmission of the data by the Series 6000. Each transmission by the controller or the DMM, shown in lines 14 through 44, requires the handshake cycle illustrated by line entries 1 through 13 of the table.

3.4.6.7 Refer to Table 3.10, line 1, and note that the first operation performed is the setting of the Remote Enable (REN) line to the low state. As explained in the table, this operation arms the bus members to go to the remote mode. The controller then transmits the interface clear (IFC) signal which stops bus activity and the attention (ATN) line is set low indicating that the next data byte placed on the bus by the controller will be a Bus Message. Note in the timing chart that when the ATN line is set low (3) that the 6000 responds by setting the NRFD line high (4). This response by the 6000 indicates that it is now ready to accept data.

3.4.6.8 When the DMM transmits the ready for data signal by setting the NRFD line high (line 4 of Table 3.10) the controller puts the bus message UNL on the data lines. As shown in line 5 of the table this is the ASCII character ?. The unlisten message is a universal message understood by all bus members as the command "unlisten". Having placed the data character on the lines, the controller now says the data is valid by setting the DAV line low (6). The DMM then says "I'm going to accept the data now on the data lines; don't change the data lines". The DMM then reads the data lines (8) and acknowledges acceptance of the data by setting the NDAC line high (9). The controller then removes the data valid signal (10), removes or changes data (11) and the DMM removes the data accepted signal from the bus (12).

3.4.6.9 At this point, one ASCII character has been transmitted by the controller to the DMM and the DMM is now ready to accept a new data byte. It indicates this (13) by setting the NRFD line high. The controller now puts the next character on the data line and the handshake cycle for the transfer of the character is repeated. The next character transmitted by the controller is the ASCII character U which is the talk address of the Hewlett-Packard 9825 calculator. As indicated in Table 3.10, by transmitting this character the calculator is making itself a talker. The next character transmitted is the quotation mark which is the listen address of the 6000 DMM when it has been assigned the decimal address 02.

3.4.6.10 Lines 16 through 24 of the table illustrate the sequence of transmission of the program string which instructs the DMM to make the DC voltage measurement. Lines 26 and 29 of the table indicate the end of transmission with the characters CR (carriage return) and LF (line feed). Note that at line 16 of the table the controller sets the ATN line high indicating that the program string to follow in lines 17 through 24 are device dependent messages.

3.4.6.11 Having transmitted the program string of device dependent messages to the DMM, the controller then sets the ATN line low which indicates that the characters to follow in lines 26 through 28 are bus messages. These bus messages change the talker/listener relationship of the controller and DMM; the DMM is made a talker and the controller becomes a listener.

3.4.6.12 Lines 30 through 44 illustrate the sequence of the transmission of data by the DMM. The handshake sequence is the same when the DMM is transmitting data as that outlined in lines 1 through 13 of the table, except that the DMM is controlling the handshake lines.

3.4.6.13 Upon completion of the data transmission, the Series 6000 transmits a carriage return (CR) and line feed (LF) to indicate the end of the data transmission.

3.4.7 Interface Message Repertoire.

3.4.7.1 The Series 6000 DMM is equipped with a standard GPIB interface which conforms to the specifications contained in IEEE-488-1975. The specification includes the definition of multi-line interface messages and this definition divides the messages into two groups: the primary command group and the secondary command group. The 6000 includes none of the secondary command group in its interface message repertoire.

3.4.7.2 The primary command group of interface messages is further broken down into four lower categories: (1) the listen address group, (2) the talk address group, (3) the universal command group and (4) the addressed command group. The 6000 is designed to include in its interface message repertoire 31 listen addresses and 31 talk addresses.

Table 3.9 - Model 6000 Interface Addressing

ASCII CHARACTERS		DATA LINES							ADDRESS SWITCH SETTING	DECIMAL ADDRESS
TALK	LISTEN	D_7	D_6	D_5	D_4	D_3	D_2	D_1	TALK ONLY A5 A4 A3 A2 A1	
		TALK	LISTEN	ADDRESS 16	8	4	2	1		
	SP	0	1	0	0	0	0	0		00
@		1	0	0	0	0	0	0		
	!	0	1	0	0	0	0	1		01
A		1	0	0	0	0	0	1		
	"	0	1	0	0	0	1	0		02
B		1	0	0	0	0	1	0		
	#	0	1	0	0	0	1	1		03
C		1	0	0	0	0	1	1		
	$	0	1	0	0	1	0	0		04
D		1	0	0	0	1	0	0		
	%	0	1	0	0	1	0	1		05
E		1	0	0	0	1	0	1		
	&	0	1	0	0	1	1	0		06
F		1	0	0	0	1	1	0		
	' (APOSTROPHE)	0	1	0	0	1	1	1		07
G		1	0	0	0	1	1	1		
	(	0	1	0	1	0	0	0		08
H		1	0	0	1	0	0	0		
	)	0	1	0	1	0	0	1		09
I		1	0	0	1	0	0	1		
	*	0	1	0	1	0	1	0		10
J		1	0	0	1	0	1	0		
	+	0	1	0	1	0	1	1		11
K		1	0	0	1	0	1	1		
	,	0	1	0	1	1	0	0		12
L		1	0	0	1	1	0	0		
		0	1	0	1	1	0	1		13
M		1	0	0	1	1	0	1		
	.	0	1	0	1	1	1	0		14
N		1	0	0	1	1	1	0		
	/	0	1	0	1	1	1	1		15
O		1	0	0	1	1	1	1		
	Ø	0	1	1	0	0	0	0		16
P		1	0	1	0	0	0	0		
	1	0	1	1	0	0	0	1		17
Q		1	0	1	0	0	0	1		
	2	0	1	1	0	0	1	0		18
R		1	0	1	0	0	1	0		
	3	0	1	1	0	0	1	1		19
S		1	0	1	0	0	1	1		
	4	0	1	1	0	1	0	0		20
T		1	0	1	0	1	0	0		
	5	0	1	1	0	1	0	1		21
U		1	0	1	0	1	0	1		
	6	0	1	1	0	1	1	0		22
V		1	0	1	0	1	1	0		
	7	0	1	1	0	1	1	1		23
W		1	0	1	0	1	1	1		
	8	0	1	1	1	0	0	0		24
X		1	0	1	1	0	0	0		
	9	0	1	1	1	0	0	1		25
Y		1	0	1	1	0	0	1		
	:	0	1	1	1	0	1	0		26
Z		1	0	1	1	0	1	0		
	;	0	1	1	1	0	1	1		27
[		1	0	1	1	0	1	1		
	<	0	1	1	1	1	0	0		28
\		1	0	1	1	1	0	0		
	=	0	1	1	1	1	0	1		29
]		1	0	1	1	1	0	1		
	>	0	1	1	1	1	1	0		30
^		1	0	1	1	1	1	0		
NONE		ILLEGAL							NONE	31

Table 3.10 - **Bus Operation Sequence**

	HANDSHAKE LINES	BUS LINES	DATA LINES	MEANING OR FUNCTION
1		REN Lo		Arms bus peripherals to go to remote mode.
2		IFC		Stops activity on the bus.
3		ATN Lo		Signifies that data byte will be a "Bus Message".
4	NRFD Hi			DMM says ready for data.
5			?	UNL (Unlisten) message (ASCII character ?) on data bus by controller means "all bus peripherals unlisten".
6	DAV Lo			Controller says data on bus is valid.
7	NRFD Lo			DMM says its not ready for new data; do not change data lines while DMM is accepting data.
8				DMM reads data lines.
9	NDAC Hi			DMM says it has read data.
10	DAV Hi		?	Controller says data no longer valid.
11	NDAC Lo			DMM removes data accepted flag.
12	NRFD Hi			DMM says it's ready for next data byte.
13				Controller removes or changes data on bus.
14			U	"I talk", controller becomes talker (HP9825 talker address).
15			"	"You listen", addressed peripheral becomes listener (In this case it is the 6000 DMM set to decimal address 02; see table 3.9).
16		ATN Hi		Signifies that data byte will be a "Device Dependent Message" as opposed to an "Interface Message".
17			F	Function
18			1	DC Volts
19			R	Range
20			5	10 Volts
21			T	Trigger
22			1	Continuous
23			CR	End of transmission by HP9825.
24			LF	
25		ATN Lo		Byte to follow is a Bus Message.
26			?	UNL (unlisten) bus message.
27			B	"You talk", 6000 talk address (02).
28			5	"I listen", HP9825 listen address.
29		ATN Hi		Message to be transmitted by DMM is Data.
30			+	Measurement data transmitted by DMM
31			1	
32			.	
33			0	
34			2	
35			5	
36			4	
37			6	
38			8	
39			E	Exponent Indicator means X 10^{01}
40			+	Sign of exponent.
41			0	Exponent. Here it indicates 10^{10}.
42			1	
43			CR	End of 6000 data message.
44			LF	

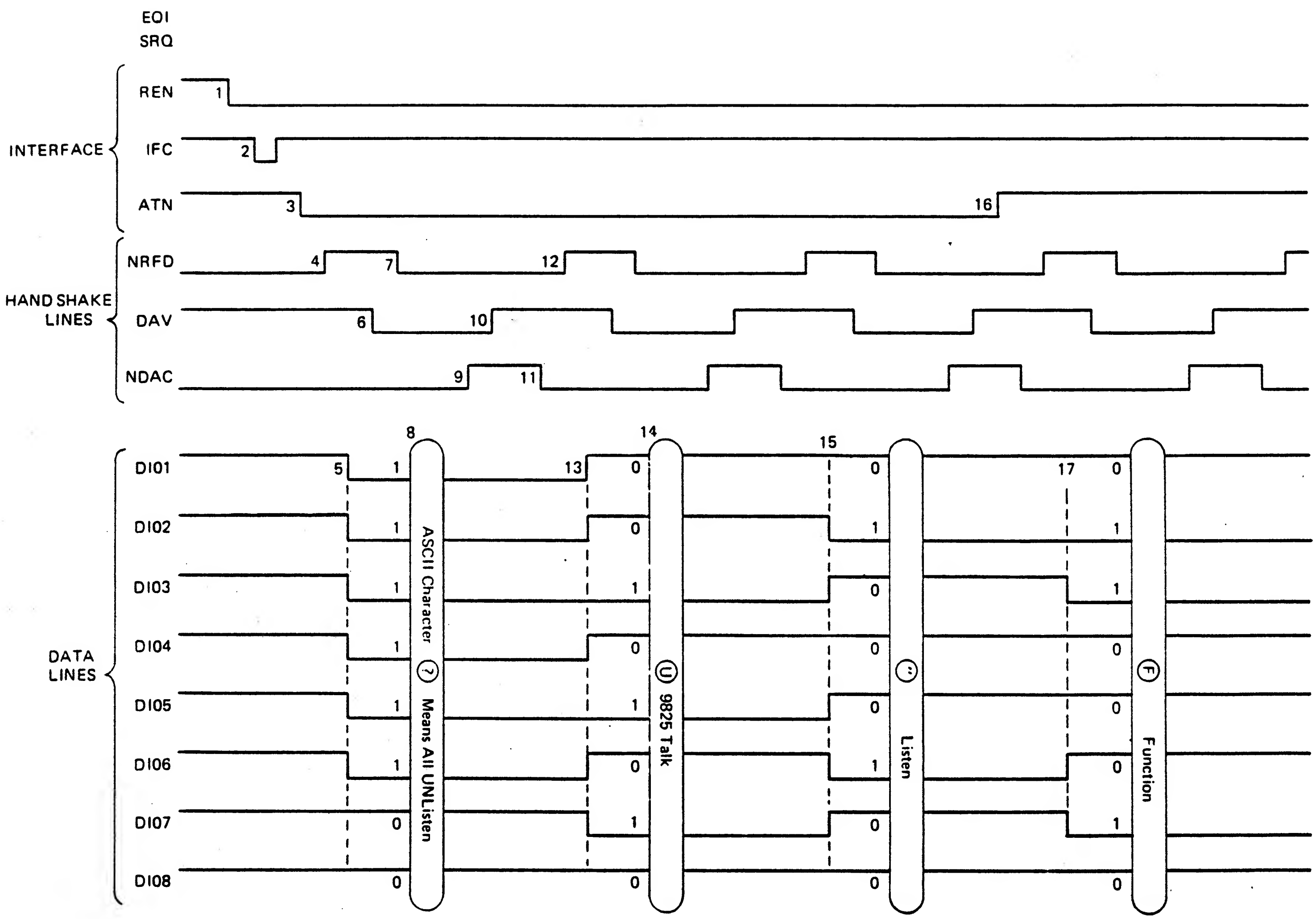


Figure 3.11 - Interface Timing

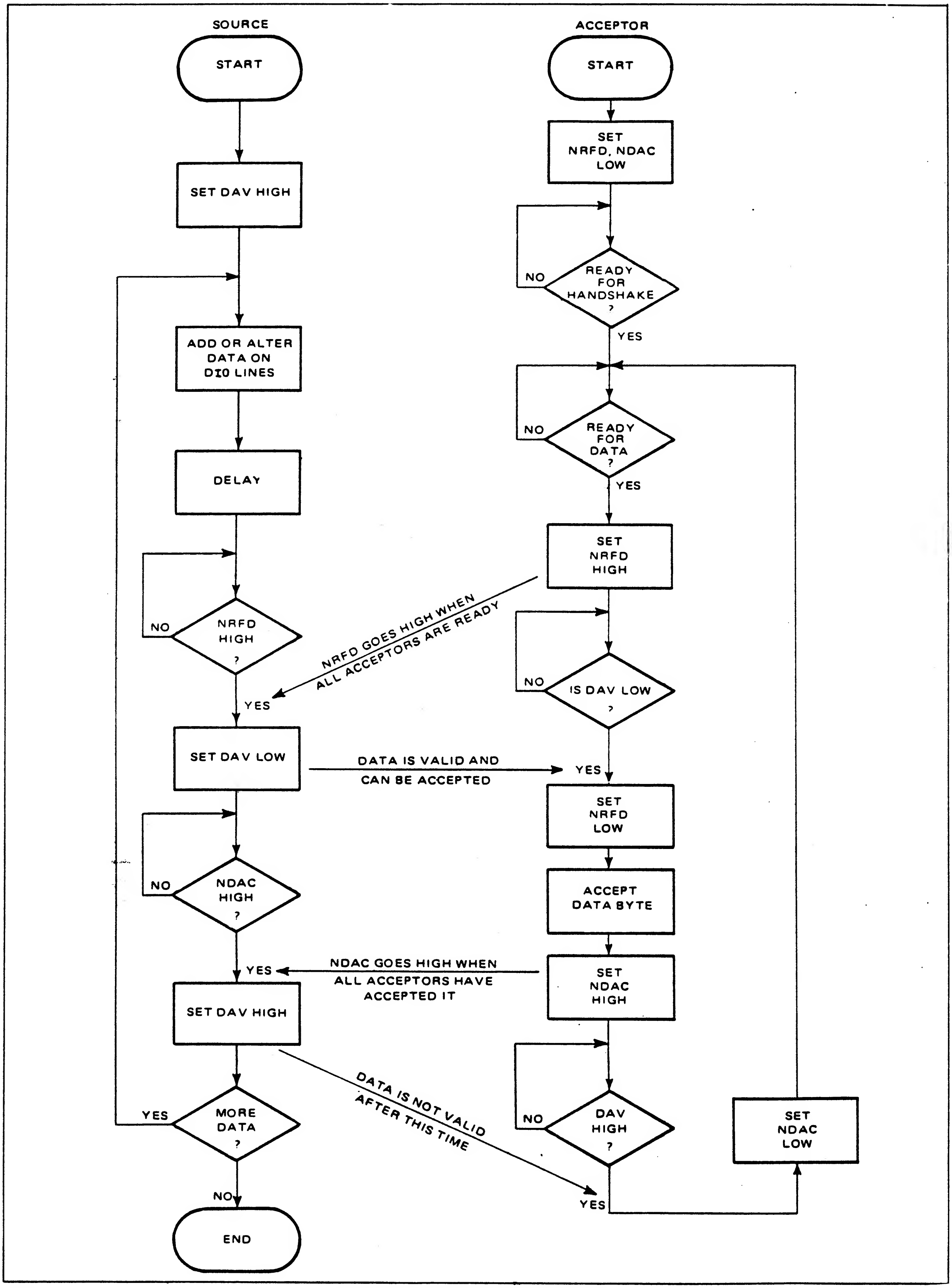


Figure 3.12 - Handshake Flow Chart

Table 3.11 - Interface Messages Used With Model 6000 DMM

Message	Meaning	HEX CODE	Decimal Equiv.	DATA LINE CODE						
				7	6	5	4	3	2	1
GTL	Go To Local	01	1	0	0	0	0	0	0	1
SDC *	Selected Device Clear	04	4	0	0	0	0	1	0	0
GET *	Group Execute Trigger	08	8	0	0	0	1	0	0	0
LLO	Local Lock Out	11	17	0	0	1	0	0	0	1
DCL	Device Clear	14	20	0	0	1	0	1	0	0
SPE	Serial Poll Enable	18	24	0	0	1	1	0	0	0
SPD	Serial Poll Disable	19	25	0	0	1	1	0	0	1
UNL	Unlisten	3F	63	0	1	1	1	1	1	1
UNT	Untalk	5F	95	1	0	1	1	1	1	1

*Instrument will ignore message unless it is a listener

The listen and talk addresses to which the 6000 may be set are listed in Table 3.9.

3.4.7.3 The interface messages to which the 6000 DMM is designed to respond are listed in Table 3.11 along with their decimal equivalents, hex equivalents, meanings and data line codes. The function of the 6000 in response to each of these commands is described in the following paragraphs.

3.4.7.4 GO TO LOCAL (GTL).

3.4.7.4.1 As shown in Table 3.11, the GTL command means go to local and the decimal and hex equivalent are both 01. Upon receipt of this interface message, the 6000, if previously programmed for remote, will return to its local operational state. This means that the instrument will then perform the function according to the settings of the front panel controls on the instrument until such time as it returns to remote control.

3.4.7.5 SELECTED DEVICE CLEAR (SDC).

3.4.7.5.1 Upon receipt of the SDC command, the 6000 will go to the home state. The decimal and hex equivalent are both 04.

3.4.7.6 GROUP EXECUTE TRIGGER (GET).

3.4.7.6.1 As shown in Table 3.11, the decimal and hex equivalents of the GET command are both 08. Upon receipt of the GET interface message, the 6000 will trigger a reading if it had previously been placed in the HOLD mode. The group execute trigger command is used to trigger the simultaneous execution of a number of functions by a number of bus members at the same time. To use this command, two or more bus members are programmed to perform a function on receiving the GET interface message or a trigger command. Subsequently, the controller will transmit the GET command and all bus members previously programmed will begin execution on receipt of the command.

3.4.7.7 LOCAL LOCK OUT (LLO).

3.4.7.7.1 The Series 6000 is armed to go to remote operation when the remote enable (REN) bus management line is set to the 1 (low) state by the controller. The 6000 may be brought back into local control by pressing the "Shift" key and then the "Local" key on the keyboard. If, however, the 6000 receives an LLO (Hex 11 or decimal 17) command while in remote operation, it may not be brought back into local control through keyboard operation.

3.4.7.8 DEVICE CLEAR (DCL).

3.4.7.8.1 The decimal equivalent of the DCL command (as shown in Table 3.11) is 20, and the hex equivalent is 14. This command is identical in operation to the SDC command except that it is a universal command and will not necessarily include the address of the 6000. When this command is transmitted on the bus, all devices on the bus which respond to the DCL will clear.

3.4.7.9 SERIAL POLL ENABLE (SPE).

3.4.7.9.1 As shown in Table 3.11, the decimal equivalent of this interface command is 24; the hex equivalent is 18. The function of this command is to cause all bus members responding to the SPE command to ready their status word. Thus, when a bus member has transmitted a service request (SRQ), the bus controller can transmit the serial poll enable command, sequentially command each bus member to transmit its status byte and thus identify the bus member requesting attention. Upon receipt of the SPE interface message, the 6000 immediately prepares to respond to a status request from the controller. If the 6000 has previously transmitted an SRQ, it will set bit 7 of the status byte to 1. The serial poll allows a bus member to set the service request line to the 1 state, thus indicating to the controller that it wants attention. The controller may then sequentially interrogate each bus member to determine which one has requested service and the purpose of the request. The meanings of the bits in the status bytes are shown in Figure 3.13.

Standard Output Format: ±D.DDDDDD E ±DD CR LF

Used for output of readings, numerical constants and when dB function is selected.

D = data byte

CR = carriage return

LF = line feed

HLL Output Format: D CR LF

For HLL categories, D = 0 through 6.

For overload, D = 9.

Serial Poll Output Byte - Bit Allocations:

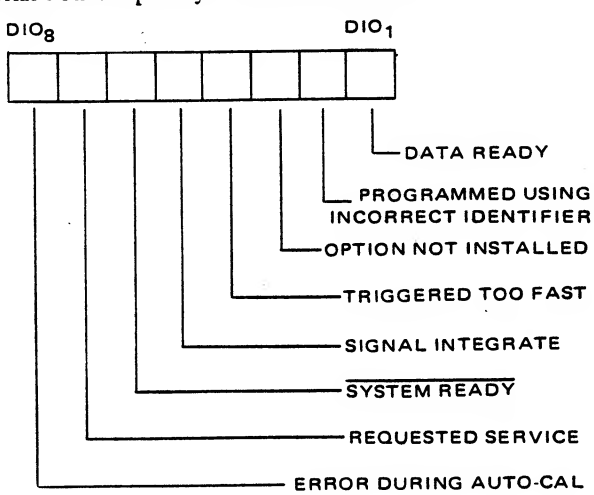


Figure 3.13 - GPIB Output Formats

3.4.7.10 SERIAL POLL DISABLE (SPD).

3.4.7.10.1 As shown in Table 3.11 the decimal equivalent to the SPD command is 25; the hex equivalent is 19. The function of this command is to return the bus members to their original states after the serial poll transaction has been completed.

3.4.7.11 UNLISTEN (UNL).

3.4.7.11.1 As shown in Table 3.11 the decimal equivalent of this command is 63; the hex equivalent is 3F. This command is also a universal interface message understood by all members of the bus as a command to go to the unlisten state. When this command is transmitted, all bus members previously in the listen state will return to the unlisten state.

3.4.8 Device Dependent Messages.

3.4.8.1 The messages which control the operation of the Series 6000 DMM when in system operation are referred to as device dependent messages. These messages are simply combinations of ASCII characters which the instrument recognizes as specific instructions. To program the instrument for a specific operation, the operator programs the controller to transmit a sequence of these messages (referred to as a program string). The program string is variable in length and has no fixed format. Individual commands may be transmitted in any order and require no delimiters or spacing for the instrument to understand. A terminator character(s) should be sent as the last character in each program string. Acceptable terminators are CR (Carriage Return), LF (Line Feed), or both. Most controllers will add these to the program string automatically. Alphabetic characters may be either upper or lower case.

3.4.8.2 The device dependent messages are listed in Table 3.12 along with the 6000 operation and any special notes that apply. The device dependent messages applicable to the Series 6000 are divided into subcategories of Function Commands and Range Commands. In general, the various commands cause the instrument to perform the same functions as the front panel controls. There are special cases however, where there are extra functions available under remote control which are not available in the bench operation mode. Further, there are some special situations re-

quiring special attention to the operation sequence used with the 6000.

3.4.8.3 To assemble a program string, first list the requirements of the program, and then select the appropriate program codes from Table 3.12. Table 3.10 shows a program string listing for a typical measurement procedure.

3.4.9 Function Commands.

3.4.9.1 Function commands are available to program the instrument to perform any operation which may be commanded through use of front panel keyboard controls. Note that in Table 3.12 the 6000 Operation column lists the functions available on the instrument and that the Program Code column shows the ASCII characters required to program the instrument for each of these functions. To program a function the controller need only transmit the ASCII characters required for the desired function (eg: to program the measurement function DC volts, the controller simply transmits the two ASCII characters F and 1 over the bus to the Model 6000).

3.4.10 Range Commands.

3.4.10.1 Ten individual range commands are available to the controller: one to command the autorange and nine additional commands for selecting specific ranges for the instrument. Note that the R1 and R2 commands both call for the 10 millivolt range when used in a program string for voltage measurements. If the instrument is commanded to go to the 10 millivolt range with the use of an R1 command it will uprange automatically to 100 millivolts if overload occurs. If the instrument is commanded to go to the 10 millivolt range with an R2 command it will remain on the 10 millivolt range even if an overload occurs. Note that the commands R1 through R9 all serve dual purposes; they command ranges for voltage measurements and for resistance measurements.

3.4.11 Trigger Commands.

3.4.11.1 Trigger commands T0 through T5 control the beginning of a measurement cycle of the series 6000.

3.4.11.2 INTERNAL TRIGGER

3.4.11.2.1 When the T1 command is transmitted, the instrument triggers itself continuously. This is shown at the top of Figure 3.14, where the program string "F1R5T1" causes multiple integrate cycles in the DMM's A/D converter.

3.4.11.2.2 When operating in the internal trigger mode, the DMM may occasionally output 2 sign bytes onto the GPIB, such as - - 1.234567E + 89. This may cause problems for some GPIB controllers, such as the commodore "PET". Depending upon the make and model GPIB controller used, one or more of the following suggestions may be helpful if problems are encountered.

a) Use the T2 command (hold mode) rather than T1.

b) Read the answer into the calculator as a string (rather than numeric) variable and perform one of the following:

   1) Test for excessive string length. If string is too long, delete the first character in the string.

   2) Test the second character to see if it is a 'plus' or 'minus' character, If so, delete the first character in the string.

3.4.11.3 EXTERNAL TRIGGER

When the T2 command is transmitted to the DMM, the instrument must be triggered by an external logic signal inputted through a BNC connector on the rear panel of the instrument. The rear BNC trigger input pulse and the resulting integrator waveform are shown in Figure 3.14.

3.4.11.4 HOLD MODE.

3.4.11.4.1 When the T3 command is transmitted, the instrument is put in the "Hold" state and will stay there until it is triggered either from the front panel or from the GPIB. Trigger commands from the GPIB can be either a T0 command or a Group Execute Trigger. Trigger commands are given from the keyboard by pressing (shift) hold when the machine is in local control.

3.4.11.5 When transmitting a T0 command or Group execute trigger to the 6000, the user may find that once in a great while the 6000 'rejects' the trigger command and issues an SRQ to the controller. Reading the serial poll status byte will then indicate that the 6000 has been triggered too fast. If this occurs, the controller can correct the situation by waiting approximately 10 milliseconds and then re-issuing the T0 or G.E.T. command.

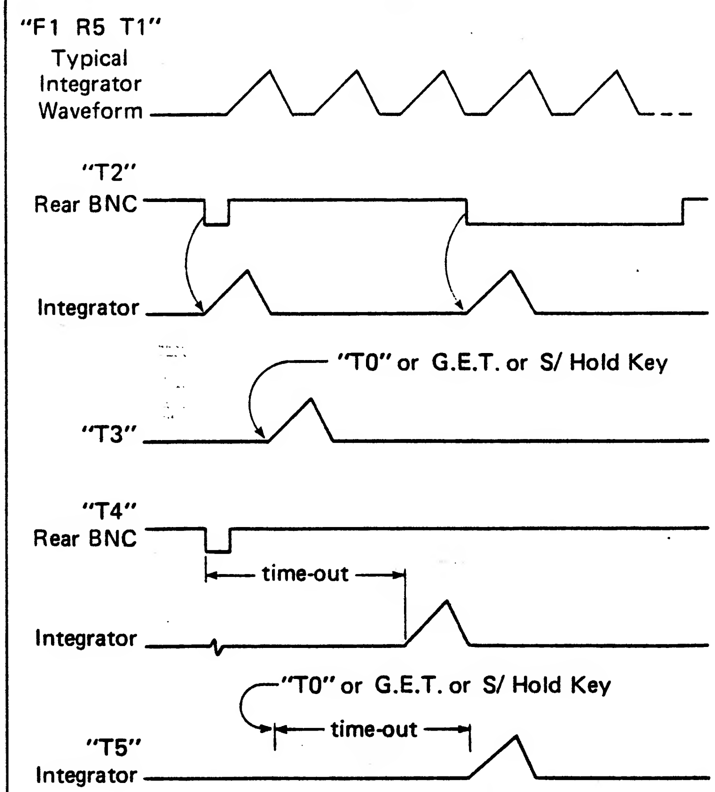
3.4.11.6 TIMEOUT COMMANDS.

3.4.11.6.1 Upon receipt of the T4 program code the instrument goes into the External Trigger mode and must be triggered by an external signal connected to the rear panel BNC connector. After being triggered via the rear panel BNC, the 6000 executes a timeout which allows time

for analog signals to settle. The timeout will vary, depending upon which functions and ranges are selected, before triggering a single reading. When program code T5 is transmitted, the instrument goes into the "Hold" mode described above except that its measurement cycle is again affected by the timeouts applicable to each function and range.

3.4.12 Integration Time Commands.

3.4.12.1 The measurement accuracy of the 6000 is directly proportional to the signal integration time (ie: the longer the integration time, the more accurate the measurement). If the measurement time is available, more accuracy may be obtained by programming the longer integration period. In situations where speed is required, the shorter integration time may be programmed at some sacrifice in measurement accuracy, see Figure 3.20. The program code IO calls for the Fast Analog-to-Digital (Fast A/D) operating mode. This mode is useable in internal trigger and external trigger modes only and, in this mode of operation, the DMM makes repeated high speed measurements and transmits the information over the GPIB. Integration time commands I1 through I5, refer to Table 3.12, call for the specific integration times shown in the 6000 Operation column of the table. Note that the Special Notes column of the table indicates the number of digits displayed for each selected integration time.



Note: G.E.T. is an abbreviation for the GPIB command "Group Execute Trigger" See Table 3.28.

Figure 3.14 - Model 6000 DMM Trigger Command Timing

3.4.13 Null Commands.

3.4.13.1 Program codes N0 through N3 call for the Null functions. The N1 program code enables the Null function. Upon receipt of N1 from the interface, a flag is set in memory which signals the Computer board to subtract the Null constant from future readings. The N2 program code allows for the storage of Null constants. Upon receipt of the N2 command, the previous reading is stored into memory for use as the Null constant. The N3 program code causes the DMM to transmit the Null constant to the controller.

3.4.13.2 The N1N2 program string accomplishes the same operation as selection of the "Shift" and "Null" keys on the keyboard. Program code N0 disables the Null function but does not change the Null constant.

3.4.14 Display Commands.

3.4.14.1 The display of measurements takes extra time in the normal measurement cycle. This time may be saved in remote operation by disabling the display feature of the 6000. To disable the numeric display, the controller need only transmit the P0 program code. This reduces the internal measurement cycle time by 3 milliseconds, thereby allowing faster read rates. To restore the front panel display, the controller transmits the program code P1. When in the I0 mode, the display should be disabled if high read rates are desired.

3.4.15 Interrupt Commands.

3.4.15.1 Commands may be transmitted by the controller to instruct the 6000 as to the transmission of SRQ signals on the GPIB. When the controller transmits the D1 code, the Series 6000 indicates the completion of each reading by sending a SRQ. If the D0 code is received, no SRQ will be sent upon completion of a reading.

3.4.16 Hi-Low Limit Commands.

3.4.16.1 The GPIB commanded Hi-Low Limit feature of the Series 6000 operates in a similar fashion to the manual or bench mode. The enabling and disabling of the HLL function is controlled by transmission of the H1 and H0 program codes respectively. In a manner similar to manual operation, the controller can enter the Hi-Low Limit constants in the HLL locations 1 thru 6 by transmitting the storage location program codes H2 through H7 respectively. For example, to store the constant 1.5 in HLL constant location 1 the controller would transmit the constant 1.5 followed by the command H2. A similar sequence would be used to store the other HLL constants 2 thru 6 in the other locations. The program code H8 is unique to remote operation in that it calls for the retrieval from storage and transmission via GPIB of the program constants. When program code H8 is transmitted to the Model 6000 DVM

the instrument retrieves the HLL constants stored in location 6 and transmits it first, followed by the remaining constants in reverse order as noted in the special notes column of the table. When using the H6 command, it should be the last command in the program string. The program code H9 initializes all six limits by setting them to ± 9.99E9.

3.4.16.2 When the HLL function is enabled, using the H1 command, the normal GPIB reading output is replaced with a single GPIB digit followed by the terminator characters CR and LF. The following shows the GPIB digit output along with its corresponding front panel LED display.

GPIB Digit:	0	1	2	3	4	5	6
LED Display:	LO	c.	b.	A	.b	.c	HI

If the reading is OL (overload), the digit "9" is output to the bus. Also, if the HLL function is enabled over the GPIB, the 7-bin display format is automatically selected. That is, the 3-bin display format of "LO," "PASS," and "HI" cannot be selected over the GPIB.

3.4.17 Filter Commands.

3.4.17.1 Control of the filter in the remote mode is the same as manual control of the filter except that the controller transmits the program code commands J0 and J1 (as shown in Table 3.12). .

3.4.18 Front/Rear Input Commands.

3.4.18.1 Selection of the Front/Rear input status is performed by transmitting the program code V0 to select the front input terminals of the instrument, or by transmitting program code V1 to select the rear input terminals.

3.4.19 External Reference Function Commands.

3.4.19.1 External reference function commands are used to select the reference used by the digital multimeter in making measurements. The controller may select the normal internal reference or an external ratio reference which may be applied to the input terminals or to the external reference connector located on the rear panel. Transmission of the X0 or X4 program codes by the controller causes the instrument to use the internal reference for all measurements. When using the instrument in the software ratio mode (DC reference), the input signal is applied to the selected input terminals as indicated by the RI lamp on the front panel. The reference is applied to the deselected input terminals, and the controller transmits the program code X1. For further explanation of input terminal selection refer to paragraph 3.3.9.4.

3.4.19.2 When using an AC reference voltage in the software ratio mode, the reference voltage is applied to the deselected input terminals and the input signal is applied to the selected input terminals. The controller then transmits program code X2 for AC coupled software ratio measurements.

3.4.19.3 It is possible to make software ratio measurements using a ratio reference voltage which is a DC voltage containing an AC component. The ratio reference voltage is applied to the deselected input terminals and the controller transmits program code X3. In this case the deselected terminals are DC coupled to the input of the instrument.

3.4.19.4 When using the instrument for hardware ratio measurements, the measurement signal is applied to the input terminals and the ratio reference voltage is applied to the connector marked EXT REF on the rear panel of the instrument. In this case, the reference voltage applied to the external reference connector is substituted for the internal reference and the program code transmitted by the controller is X5. In a similar fashion, an AC ratio reference voltage may be applied to the external reference connector. In this case the controller must transmit the program code X6.

3.4.19.5 The ratio reference voltage used with the hardware ratio mode of operation may be a DC voltage containing an AC component. In this case it is connected to the rear EXT REF connector and the program code transmitted by the controller is X7.

3.4.20 External Reference Range Commands.

3.4.20.1 There are six ranges for external reference voltages applied to the external reference connector on the rear panel of the instrument. These are the 10 millivolt* through 1000 volt ranges listed in Table 3.12 under the 6000 Operation column. When using an external reference voltage in the remote mode, the controller must transmit the appropriate program code Y2* through Y7 to select the correct range for the external reference signal.

3.4.21 Min-Avg-Max Commands.

3.4.21.1 The Min-Avg-Max (MAM) commands used in remote operation allow operation of the instrument in exactly the same fashion as the MAM modes under manual operation. The program codes M0 through M6 listed in Table 3.12 are the equivalent of the keyboard controls used to operate the MAM feature of the instrument. To

*Y2-10mV range available only if Option 41 (preamp) installed.

perform a MAM measurement the controller must transmit a series of program strings as outlined in the following paragraph.

3.4.21.2 To initiate the MAM cycle, the controller must transmit the program code M6. This is equivalent of depressing the "Shift" and "MAM" keys on the keyboard. At the end of the desired measurement period, the controller should transmit the M0 program code to disable the MAM function. To acquire the results of the MAM measurement, the controller must call for each data result separately. This means the controller must transmit the program code M2, make the DMM a talker so that it can transmit the Min measurement value, make the DMM a listener so that it can be programmed with the M3 program code and thereby transmit the Avg measurement value and so on for each of the four measurement results from the MAM measurement cycles. Thus, for the controller to make a complete MAM measurement and acquire all the resulting data, the controller must transmit six program instruction strings; two (M6 and M0) to start and stop the MAM function followed by the M2 through M5 function codes to call for the results. The 6000, in turn, must transmit four measurement values: the minimum, the average, the maximum and the number of measurement samples.

3.4.21.3 When using MAM in conjunction with the GPIB, certain precautions should be taken to ensure that the 6000 isn't commanded over the bus while the Average is being up-dated internally. If the Average calculation is disrupted by GPIB programming, the accuracy of the average constant cannot be guaranteed, although the minimum, maximum and number of readings constants will not be jeopardized. For this discussion, all commands listed in Table 3.12 of the Operator's Manual are considered to be GPIB programming commands. It should be pointed out, however, that GPIB interface commands (such as Serial Poll) will not affect the accuracy of the average constant.

3.4.21.4 In order to guarantee the accuracy of the average constant, the programming of the MAM function should be handled as follows:

a. Program the MAM function as usual using the M1 or M6 command.

b. Delay as usual.

c. Via the GPIB, Program the 6000 to be a talker and take two readings from it. These two readings can then be thrown away.

d. Reprogram the 6000 as usual.

Steps should be taken to prevent delays of more than 10 milliseconds from occurring anywhere during or between steps c. and d. above. These steps may include the disabling of interrupts inside the controller and the execution of items c. and d. in succession.

3.4.21.5 This procedure guarantees that the 6000 will not be in the average calculation when reprogrammed via the GPIB. An HP 9825A example program using this procedure is shown.

`0: wrt 700,"z1t1 m1"`	Command 6000 to: Z1 initialize T1 internal trigger M1 MAM function
`1: wait 5e3`	Delay while readings are taken
`2: red 700,Z` `3: red 700,Z`	Take 2 readings
`4: wrt 700,"m0"` `*21560`	Remove from MAM function

3.4.22 Calibration Commands.

3.4.22.1 The Series 6000, in normal manual or remote operation, automatically goes into a self calibration cycle (Auto-Cal) on a predetermined time schedule. In order to disable the Auto-Cal the controller must transmit program code K0. To reestablish the Auto-Cal timing the controller transmits program code K1. To command an immediate Auto-Cal the controller transmits program code K2.

3.4.22.2 When commanding autocals from a controller, the programmer needs to know when the autocal has finished so that he can continue program execution. The best way to do this is to command the autocal and trigger the 6000 and then wait for the 6000 to output the resulting reading. For

```
0: wrt 700,"k2t3
 t0"
1: red 700,Z
```

example, in the calculator program shown above, the 6000 is programmed to the hold mode (T3), an autocal is commanded (K2), and a reading is triggered (T0). The controller then waits for the reading to be transmitted to it from the 6000, which is an indication that the autocal has completed. The reading may then be processed as usual. If the programmer wishes to receive an SRQ when the autocal has completed, the D1 command may be added to the program string in the above example.

3.4.23 Equation Command.

3.4.23.1 To enter the instrument into the arithematic mode of operation, the controller must transmit the program code Q1. Upon receipt of this command, the instrument will perform the arithematic equation using the constants in storage. Before calling for the equation function, the controller should transmit any constants required for use in the equation or arithematic functions. If no constants have been transmitted and stored, prior to transmission of the program code Q1, the equation will have no effect on the present reading. This results when initialization sets the A constant at 0 and the constants B and C to 1.

3.4.24 Variable Manipulation Commands (A, B or C).

3.4.24.1 In a manner similar to that for manual operation, the controller can store or clear all arithmetic variables used in the mathematics equation. The codes for storing, clearing or the transmission of the variables are shown in Table 3.12. For example, to store 1.25 in the constant "A" location the controller must transmit 1.25A1.

3.4.25 Initialization Commands.

3.4.25.1 The controller can initialize the Series 6000 much in the same manner that the operator would use. In manual mode, the operator may depress the "Shift" and "Initialize" keys. This puts the instrument into the initialized state. The instrument can be initialized from the GPIB by using the command code Z1.

3.4.25.2 The Z1 command is equivalent to the program string F1, R0, T3, N0, P1, H0, J0, X0, M0, Q0, W0. The initialization command causes Null, HLL, MAM, Filter, Equation [(X-A)B/C] and Status Output (of Cal constants) to be disabled. Internal Reference and Numeric Display to be enabled and sets the DMM to DC Volts, Autorange and Hold condition.

3.4.26 Fast Analog-to-Digital (Fast A/D) Operation.

3.4.26.1 Measurement information can be obtained and transmitted at a high speed rate if the Fast A/D mode is used (Option 03 or 03SH).

3.4.26.2 GENERAL OPERATION PROCEDURES.

3.4.26.2.1 When programming the Fast A/D from the GPIB, it is important to note that program codes will produce a delay period before the 6000 is able to begin taking readings from the Fast A/D. Each command string sent to the 6000 will cause a delay of 1 timeout (reference Table 3.19) plus approximately 3 milliseconds. As an example, if the 6000 is in the DC function, then any command string sent to the DMM will cause a timeout of 30 milliseconds (for the DC function) plus approximately 3 milliseconds. After the command string has been executed and the 33 millisecond delay is completed, the 6000 will begin to take readings from the Fast A/D.

3.4.26.2.2 For most Fast A/D GPIB applications, the PØ command (disable front panel) should be used in conjunction with the IØ (Fast A/D) command. The PØ command will disable both the display and the keyboard of the 6000. If an IØ PØ command is sent by the controller, then a P1 command (enable front panel) must be sent before the 6000 is returned to local operation.

3.4.26.3 INTERNAL TRIGGER.

3.4.26.3.1 The Fast A/D can be programmed to trigger internally by sending the command string IØ PØ T1 to the 6000. The time between readings may then be controlled via the S command (delay).

3.4.26.3.2 In order to operate the Fast A/D at the fastest conversion rate, the controller should transmit ØØØ S1 which indicates no A/D delay. The numbers preceding the S1 command may range from ØØØ thru 255 (reference Table 3.12 for the delay formula).

3.4.26.3.3 As shown in Figure 3.27, the Fast A/D information is transmitted over the GPIB in two bytes by the 6000. Bits 1 thru 6 of each byte contain the data information (in two's complement), and bit 8 (DIO_8) is the byte identification bit (1 for the first byte and Ø for second byte).

3.4.26.3.4 The controller must be fast enough to accept each byte as it becomes available from the 6000. Therefore, the controller has to be faster than the 6000 in order to guarantee that no data will be lost. If the controller is too slow to accommodate the data rate of the 6000 certain bytes of the data will include a 1 in the overrun flag position (DI07).

3.4.26.3.5 If the overrun bit is detected, the delay between readings should be increased by programming a larger delay constant as referenced in paragraph 3.4.26.3.2 and Table 3.12.

3.4.26.4 EXTERNAL TRIGGER.

3.4.26.4.1 The Fast A/D can be programmed to wait for an external trigger by sending the command string IØPØ T2 to the 6000. The time between readings may then be controlled by applying trigger pulses to pin 14 or pin 15 of the Fast A/D or Sample and Hold Fast A/D connector.

3.4.26.4.2 When the 6000 is in the external trigger mode, the external triggers will be ignored until the internal delay period is completed (reference paragraph 3.4.26.2.1). At the end of the delay period, the 6000 will monitor the Fast A/D, waiting for an external trigger. The 6000 transmits the GPIB data bytes in the same format as described in subsection 3.4.26.3, except that the DIO_7 bit is always Ø.

3.4.26.4.3 If the external trigger rate exceeds the rate at which data bytes are taken from the 6000, then the DMM will output only the first byte of each two byte data word.

3.4.27 dB Commands.

3.4.27.1 Decibel measurement is handled in the remote mode very much the same as in bench operation mode. To enable dB measurement the controller transmits program code L1. To disable the function the controller transmits

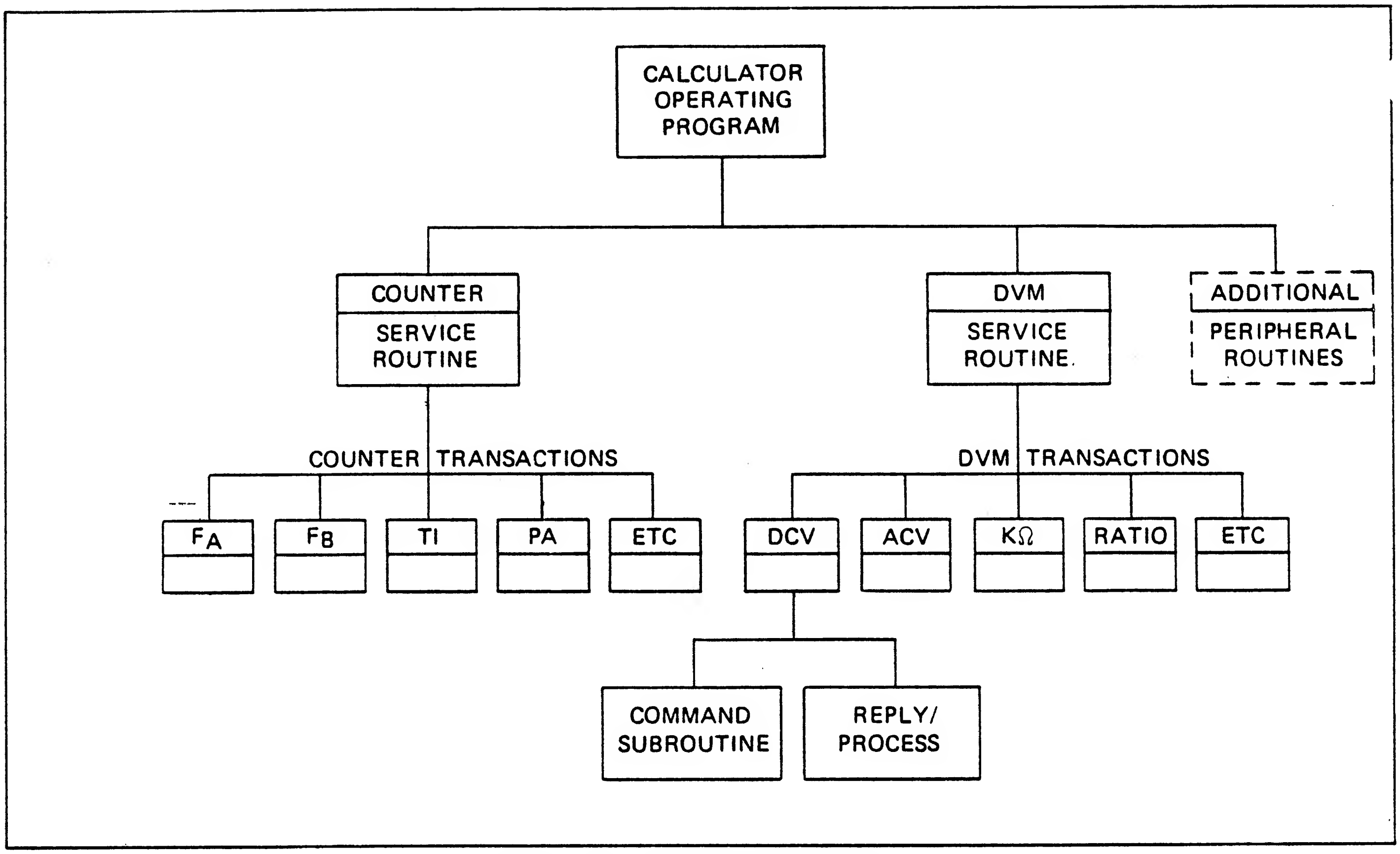


Figure 3.15 - Software Organization

LO. Just as in the bench operation mode the controller can change the value of the internal reference resistor from its normal 600 ohm value to a new desired value by transmitting the value followed by the program code L2.

3.4.28 Software Organization.

3.4.28.1 The following paragraphs are presented to acquaint the operator with the device messages used when operating the 6000 DMM and to explain the relationship of these device dependent messages to the user's overall software package.

3.4.28.2 A calculator, computer or other controller device software package usually includes a collection of transactions, service routines and subroutines for controlling all of the elements of a system. The relationship of the various parts of a typical software operating system are illustrated in Figure3.15. A complete operating system may include the main executive program, the keyboard monitor program, some form of statistical routine, an arithmetic or decision making routine and a set of peripheral servicing routines. Figure 3.15 illustrates a portion of a software package referred to as an operating system. The portion illustrated is a typical collection of peripheral service routines. These peripheral service routines are groups of subroutines known as transactions. Note that the illustration shows a service routine for a counter, a digital voltmeter and a number of additional peripheral equipments. A DVM service routine for the Series 6000 might include a number of transactions depending on the application of the instrument in the system. Each transaction will include the bus commands and device messages necessary to accomplish the specific function for each transaction. Note that the transactions shown are for DCV (DC volts), ACV (AC volts), KΩ (kilohms), Ratio and any number of other transactions necessary for the particular counter application. Note that under the DCV transaction block a further breakdown is illustrated: that of the command subroutine and the reply or process subroutine. This is the point in the overall software structure that the 6000 device messages appear.

3.4.28.3 VOLTMETER TRANSACTIONS.

3.4.28.4 Figure 3.16 illustrates a typical voltmeter transaction designed to operate the Series 6000. The left-hand column of the illustration titled Bus Action or Message contains a sequence of bus control line titles and device characters. The second column of the illustration indicates

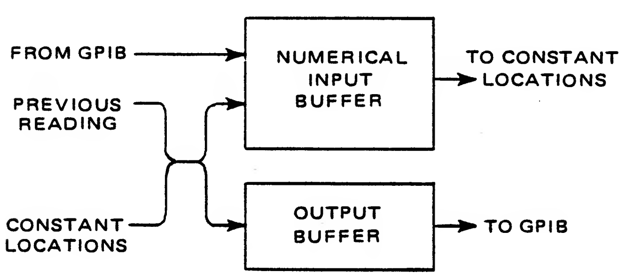
whether the controller or the DMM is controlling the bus or transmitting the characters. This column is titled Active Unit or Talker. The boxes to the right of the second column identify the portion of the transaction as the command subroutine or the reply subroutine. Note that the command portion of the transaction includes an interface message which establishes the talker/listener relationship and the device dependent message which instructs the DMM to perform a specific operation. Once the peripheral, in this case the 6000 DMM, has been programmed to perform a function, the controller transmits the second interface message to reestablish the listener/talker relationship and the 6000 makes the measurement and transmits the data over the interface bus.

3.4.29 Constant Manipulation From The GPIB.

3.4.29.1 There are 10 constant storage locations inside the 6000 which can be used regardless of whether the corresponding mode is selected or not. These locations are:

NULL
A
B
C
HLL_1 - HLL_6

3.4.29.2 Two main buffers are used in GPIB operation. The output buffer holds the ASCII characters which are waiting to be transmitted to the controller. The input buffer has two uses. During the entry of numerical constants from the bus, the input buffer is used as the holding register. Also, the input buffer is used to hold the number which was most recently transferred to the output buffer. For instance, if given the command N2, the input buffer will contain the value of the null constant. Also, the output buffer will contain the ASCII characters corresponding to the null constant. If a reading is taken, it will be placed in both the input and output buffers.



Bus Action or Message	Active Unit or Talker	Transaction	
IFC		Interface Message	COMMAND Subroutine
ATN			
UNLISTEN	C		
I TALK	C		
YOU LISTEN	C		
F1	C	Device Dependent Message Command Characters	
R5	C		
T1	C		
ATN		Interface Message	REPLY Subroutine
UNLISTEN	C		
YOU TALK	C		
I LISTEN	C		
+	6000	Peripheral Message Reply (Data, Status) Characters	
1			
.			
0			
2			
5			
9			
6			
8			
E			
+			
0			
1			
CR			
LF	6000		

Figure 3.16 - 6000 DMM Transaction For DC Volts Measurement

3.4.29.3 Whenever a 'store' command such as H3 or A1 is executed, the present contents of the input buffer are stored in the given location. For instance, if a reading is completed and then a B1 command is given, the reading will be stored in B. If the command −2.05E−7A1 is executed, −2.05E−7 will be stored in A. A constant can be transferred from one location to another as follows: 1) move the constant to the buffers by using a transmit command, 2) transfer the contents of the input buffer to the new location with a store command. As an example, C2H4 moves the contents of C into HLL3 without disturbing C.

3.4.29.4 Whenever transfer of multiple constants over the bus (to the Model 6000) is required, the constants should be separated from each other by a CR (carriage return), a LF (line feed) or both. With most controllers this places a limit of one constant to the bus per command string.

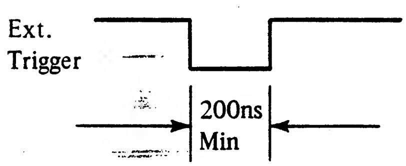
3.4.30 External Trigger.

3.4.30.1 DMM can be triggered via rear panel BNC connector after being placed in the 'Hold' mode via the keyboard (see Table 3.2 reference 23) or after having received a T2 or T4 command via the GPIB (see Section 3.4.11).

Logic Compatability: TTL
Required Drive Capability

Source: 0 mA
Sink: 2 mA

Required Timing:



Maximum Fall Time: 1μS

Delay between falling edge of external trigger and start of reading: < 1μS

NOTE

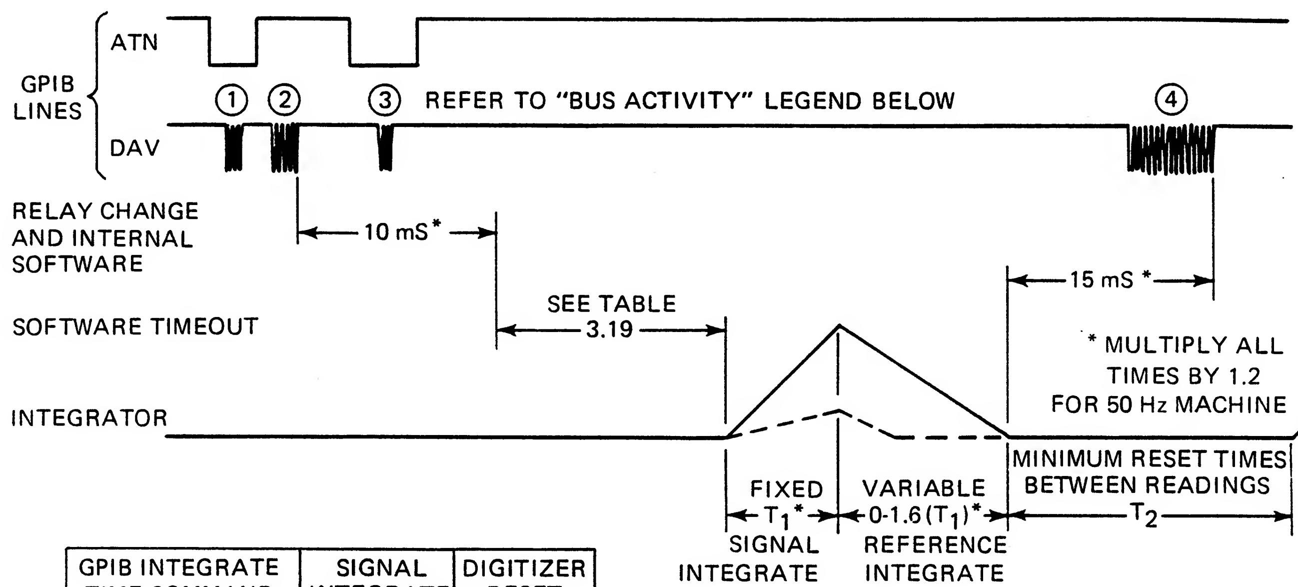
If a mechanical switch is used to generate the external trigger, contact bounce should be limited to 10μS at the waveform's falling edge and 0μS at the rising edge.

3.4.31 Read Rate Time Estimate.

3.4.31.1 The following GPIB Read Timing Program using the Hewlett Packard HP9825 calculator is presented as one example to estimate the DMM's throughput when successive readings are taken on different functions and ranges. This program string allows the programmer to estimate the time necessary to program the 6000 to a Function or Range, settle to 0.01%, take a reading, and output the reading to the bus.

Program String: Wrt 700, "FIR5"; red 700, A

3.4.31.2 Figure 3.17 shows the two GPIB lines ATN and DAV (Attention and Data Valid) along with the DMM's integrator waveform which indicates when a reading takes place. Also shown are the other delays needed to calculate the DMM's throughput time. From the figure, the total time = (10 ms) + (timeout time) + (signal integrate) + (reference integrate) + (15 ms).



GPIB INTEGRATE TIME COMMAND (FROM TABLE 3.12)	SIGNAL INTEGRATE TIME, T_1*	DIGITIZER RESET TIME, T_2*
I1	1.66 mS	5 mS
I2	4.16 mS	5 mS
I3	16.6 mS	5 mS
I4	41.6 mS	200 mS
I5	100 mS	100 mS

BUS ACTIVITY:

① CONTROLLER MAKES 6000 INTO LISTENER

② CONTROLLER SENDS F1R5T1 TO 6000

③ CONTROLLER MAKES 6000 INTO TALKER

④ 6000 OUTPUTS READING TO THE BUS

NOTE: NOT DRAWN TO SCALE; ALL NUMBERS ARE APPROXIMATE

Figure 3.17 - Program/Read Timing Chart

Table 3.12 - Model 6000 GPIB Programming Codes

INTEGRATION TIME COMMANDS

6000 Operation	Program Code	Special Notes
Fast A/D	I0	Usable in internal trigger and external trigger modes only (T1, T2).
1.6 mS Integration Time	I1	4 1/2 digit display; automatically initiates Auto-Cal.
4 mS Integration Time	I2	5 1/2 digit display; automatically initiates Auto-Cal.
16 mS Integration Time	I3	
40 mS Integration Time	I4	6 1/2 digit display; automatically initiates Auto-Cal.
100 mS Integration Time	I5	

NULL COMMANDS

6000 Operation	Program Code	Special Notes
Disable Null	N0	
Enable Null	N1	Subtracts null constant from reading.
Store as Null	N2	Stores previous reading or entered constant as null constant.
Transmit Null	N3	Output null constant to GPIB.

Table 3.12 - Model 6000 GPIB Programming Codes (continued)

DISPLAY COMMANDS

6000 Operation	Program Code	Special Notes
Disable Numeric Display	P0	Reduces internal DVM cycle time by 3 ms for faster read rates, etc.
Enable Numeric Display	P1	

INTERRUPT COMMANDS

6000 Operation	Program Code	Special Notes
No SRQ when Data Ready	D0	
SRQ when Data Ready	D1	Informs controller when reading is ready to output to the GPIB

FUNCTION COMMANDS

6000 Operation	Program Code	Special Notes
DC Volts	F1	
AC Volts	F2	
AC Volts, DC Coupled	F3	RMS AC converter must be installed.
Ohms	F4	

RANGE COMMANDS

6000 Operation	Program Code	Special Notes
AUTO Range	R0	
10mV-1Ω	R1	Upranges automatically to 100 mV if overload occurs.
10mV-10Ω	R2	Remains on 10 mV range if overload occurs.
100mV-100Ω	R3	
1V-1KΩ	R4	
10V-10KΩ	R5	
100V-100KΩ	R6	
1000V-1MΩ	R7	
Auto-10MΩ	R8	
Auto-100MΩ	R9	

Table 3.12 - Model 6000 GPIB Programming Codes (continued)

TRIGGER COMMANDS

6000 Operation	Program Code	Special Notes
Trigger Immediate	T0	Normally used in conjunction with T3.
Internal Trigger	T1	Causes continuous readings.
External Trigger	T2	Waits for trigger from rear panel BNC or from Fast A/D trigger input.
Hold/Manual	T3	Waits for trigger from GPIB or from keyboard.
External Trigger with Timeouts	T4	Same as T_2 and T_3, except that an internal time delay is inserted to allow for analog settling times
Hold/Manual with Timeouts	T5	

EQUATION COMMAND

6000 Operation	Program Code	Special Notes
No Equation	Q0	Returns to normal operation.
Perform Equation $\frac{(X-A)B}{C}$	Q1	Enables offset and scaling.

VARIABLE MANIPULATION COMMANDS (A, B, or C)

6000 Operation	Program Code	Special Notes
Clear Constant	A0 or B0 or C0	A0 sets A to zero; B0 or C0 set B or C to 1.0.
Store as Constant	A1 or B1 or C1	Stores previous reading or entered constant into A, B, or C.
Transmit Constant	A2 or B2 or C2	Outputs present value of A, B or C to the bus.

INITIALIZE COMMANDS*

6000 Operation	Program Code	Special Notes
Initialize	Z1	Same as F1 R0 T3 N0 P1 H0 J0 X0 M0 Q0 W0 F1 DC R0 Autorange T3 Hold Mode N0 Disable NULL P1 Enable Display H0 Disable HLL J0 Disable Filter X0 Disable Ext. Ref. M0 Disable MMM Q0 Disable (X-A)B/C W0 Disable Status Output

* Note that a Z1 command differs slightly from the keyboard command "Initialize".

Table 3.12 - Model 6000 GPIB Programming Codes (continued)

EXTERNAL REFERENCE RANGE COMMANDS

6000 Operation	Program Code	Special Notes For use with "X" commands		
10mV*	Y2*	DC software ratio only.		These reference ranges permitted with "X1".
100mV	Y3			
1V	Y4		These reference ranges OK with "X2", "X3", "X6", "X7".	
10V	Y5	This reference range selected automatically with "X5".		
100V	Y6			
1000V	Y7			

*Available only if Option 41 (Preamp) installed.

MIN-AVG-MAX COMMANDS

6000 Operation	Program Code	Special Notes
Disable MAM	M0	Returns to normal operation.
Clear & Enable MAM	M1	Initializes MIN, AVG, MAX and enables MAM.
Transmit MIN	M2	Outputs MIN to the GPIB.
Transmit AVG	M3	Outputs AVG to the GPIB.
Transmit MAX	M4	Outputs MAX to the GPIB.
Transmit Number of Samples	M5	Outputs Number of Samples to the GPIB.
Enable MAM	M6	Enables MAM without initializing the MIN, AVG or MAX.

CALIBRATION COMMANDS

6000 Operation	Program Code	Special Notes
Disable Auto Cal	K0	Prevents Auto-Cal from occurring automatically.
Normal Auto Cal Timing	K1	Allows Auto-Cal to initiate themselves automatically.
Do Auto Cal Now	K2	Perform an Auto-Cal immediately.

Table 3.12 - Model 6000 GPIB Programming Codes (continued)

FAST A/D DELAY COMMANDS

6000 Operation	Program Code	Special Notes For use with "I0" and "T1" commands
Clear Delay	S0	Same as "000S1"; sets fast A/D delay = 0 and inhibits data overrun error check.
Store Delay	S1	"nnnS1" stores a delay constant where nnn is between 000 and 255. A non-zero delay enables data overrun error check. "S0" or "0S1" gives a delay of 79 μs. "nnnS1" gives a delay of (95+ nnn • 44) μs. 60 Hz line voltage only "S0" or "0S1" gives a delay of 95 μs. "nnnS1" gives a delay of (114+ nnn . 52.8) μs. 50 Hz line voltage only

dB COMMANDS

6000 Operation	Program Code	Special Notes "H1" and "L1" cannot be performed simultaneously
dB Disable	L0	Returns to normal operation.
Enable dB	L1	Enables dB function.
Store as dB Resistance	L2	Stores the previous reading or entered constant as the reference resistance for dB calculations.

STATUS OUTPUT COMMANDS

6000 Operation	Program Code	Special Notes
No Status Output	W0	Returns to normal operation.
Output Cal Constants for this function and range	W1	Outputs positive offset, negative offset, positive and negative scale factors (4 constants) and then returns to normal operation. When using W1 it should be the last command in the program string.

FAST A/D CONFIGURATION COMMANDS

6000 Operation	Program Code	Special Notes For use with S/H Fast A/D
Fast A/D to Isolator	G0	Connects Fast A/D input to DVM input terminals via the isolator.
Fast A/D to rear connector	G1	Connects Fast A/D input to Fast A/D connector on back panel.

Table 3.12 - Model 6000 GPIB Programming Codes (continued)

HIGH-LOW-LIMIT COMMANDS

6000 Operation	Program Code	Special Notes "H1" and "L1" cannot be performed simultaneously
Disable HLL	H0	Returns to normal operation.
Enable HLL Function	H1	See text for description of output format.
Enter HLL Constants 1 thru 6	H2 thru H7	Stores the previous reading or an entered constant as HLL 1 thru HLL 6.
Transmit all 6 Constants	H8	Transmitted in reverse order (HLL6...HLL1) over the GPIB When using H8 it should be the last command in the program string.
Initializes HLL Constants 1 thru 6	H9	HLL constants are cleared.

FILTER COMMANDS

6000 Operation	Program Code	Special Notes
Filter Out	J0	
Filter In	J1	Selects the 4-pole active filter.

FRONT/REAR INPUT COMMANDS

6000 Operation	Program Codes	Special Notes
Front Input	V0	Measurements taken from the front input terminals.
Rear Input	V1	Measurements taken from the rear input terminals.

EXTERNAL REFERENCE FUNCTION COMMANDS

6000 Operation	Program Code	Special Notes
Internal Reference	X0 or X4	Normal mode of operation.
Software Ratio DC	X1	Reference applied to input terminals which were not selected via the "V" command.
Software Ratio AC	X2	
Software Ratio AC, DC Coupled	X3	
Hardware Ratio DC	X5	Reference applied to external reference terminals.
Hardware Ratio AC	X6	
Hardware Ratio AC, DC Coupled	X7	

3.5 PARALLEL BCD OPERATION.

3.5.1 This subsection presents information on the Parallel BCD operation in the 6000.

3.5.2 Printer Output J212.

3.5.2.1 Through this connector the 6000 supplies BCD representations of the decimal display; various flags or indicators of the mode of operation, function and range; and a print command. Provision has also been made for 60 Hz instruments to accept a fast (17 readings per second maximum) or a superfast (50 readings per second minimum) read command. In 50 Hz units, the fast command obtains 14 readings per second, minimum, and the superfast command 49 readings per second.

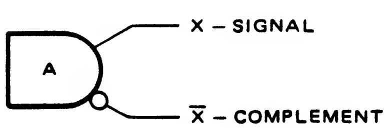
3.5.3 Program Input J209.

3.5.3.1 Through this connector the 6000 receives externally generated signals that select the function, range, mode of operation, auto calibration and initiate the read commands.

3.5.4 Logic Levels And Electronic Interface.

3.5.4.1 TTL-compatible positive-true logic levels are used in the 6000. In some instances, however, complementary signals are used. These terms are more specifically defined below:

Signals and Their Complements –



WHERE:

X	$\overline{X}$
1	0
0	1

3.5.4.2 If the non-inverting output of gate A is defined as signal X, then it follows that the inverting output is $\overline{X}$; in other words, the complement of X is $\overline{X}$. The truth table shows that the two signals X and $\overline{X}$, are by definition, in opposite logic states (see Table 3.13).

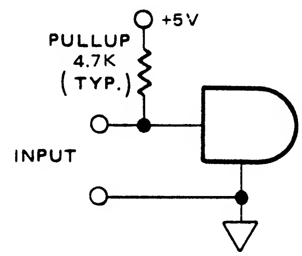
Table 3.13 - Positive True Logic Relationships

Signal	Logic State	Voltage Level of Output Line "X"	Voltage Level of Output Line "$\overline{X}$"
"X"	True or "1"	2.4 - 5.0 Volts	0.0 - 0.4
	False or "0"	0.0 - 0.4 Volts	2.4 - 5.0

3.5.4.3 As seen above, if gate A has a true or "1" level on output X, its voltage level is the most positive of the two ranges present, and output $\overline{X}$ must be in a false or "0" state with the lowest or most negative voltage range present. The reverse would be true for a false or "0" level on output X.

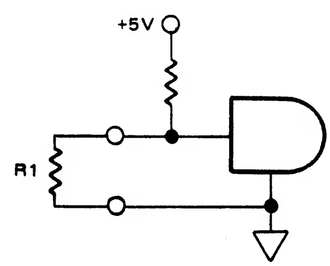
3.5.4.4 DRIVING THE INPUTS.

3.5.4.4.1 All inputs are low power schottky TTL compatible and most are the equivalent of one 74LS series TTL input with a pull-up resistor for contact closure operation.



3.5.4.5 TTL LOADING CONDITIONS.

3.5.4.5.1 To input a "1" level the pull-up resistor will supply the necessary source current (40 μA) to maintain the minimum 2.4 volts. In fact, the pull-up resistor will maintain a one level as long as the input source resistance (R1) to ground is greater than 7.5K ohms.



3.5.4.5.2 To input a "0" level, at least .5 ma of current must be sinked maintaining the input voltage below 0.4 volts. This requires a resistance to ground of 800 ohms or less.

3.5.4.6 EXCEPTIONS TO INPUT LOADING CONDITIONS.

a. $\overline{\text{Program Storage}}$ Input (J209, pin B-18) is the standard TTL inputs and requires a minimum 2 ma sinking current, or 200 ohms or less to common.

b. Maximum input voltage level, referenced to common, must not exceed 5.5 volts peak. Otherwise, gate destruction will occur.

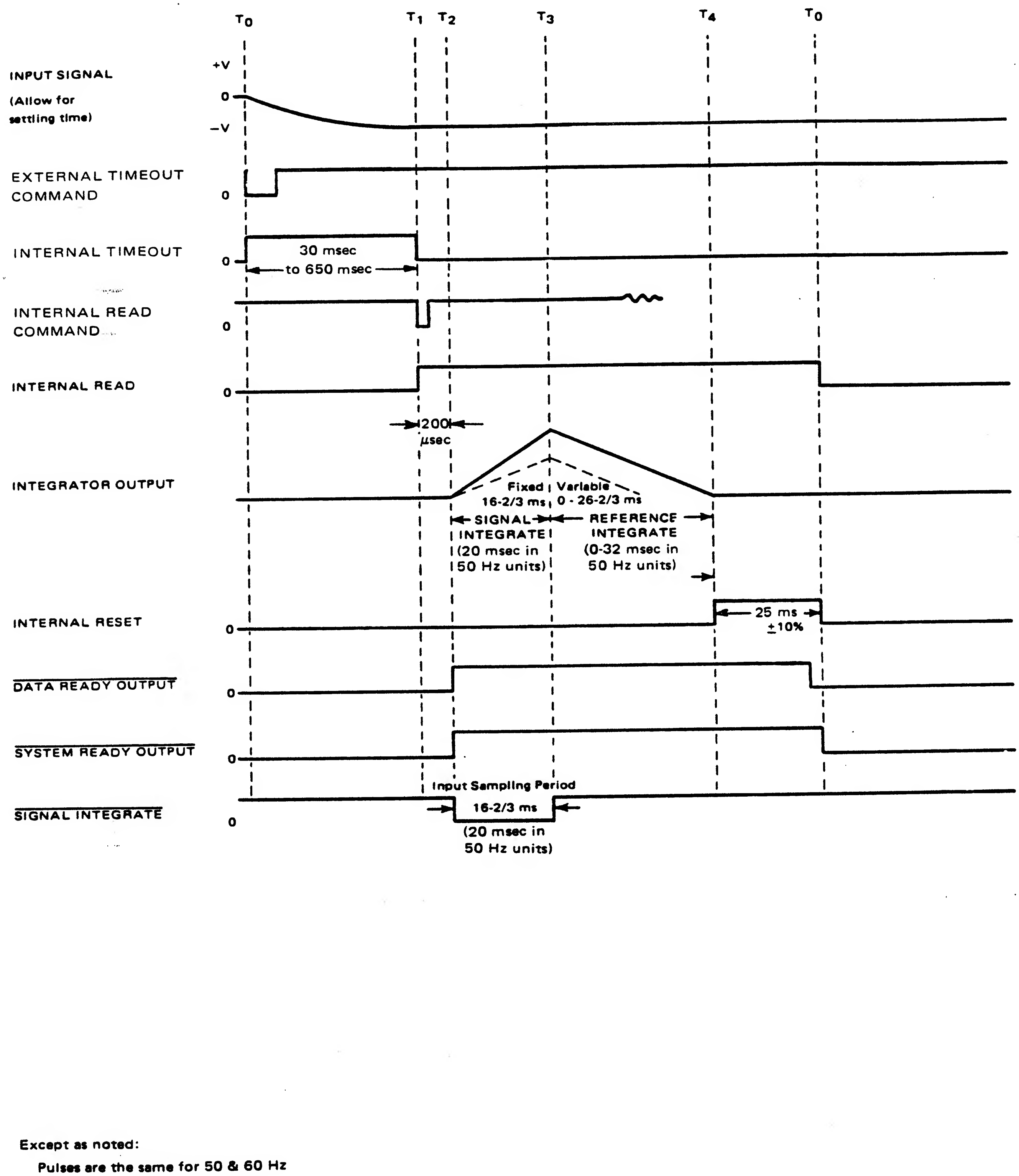
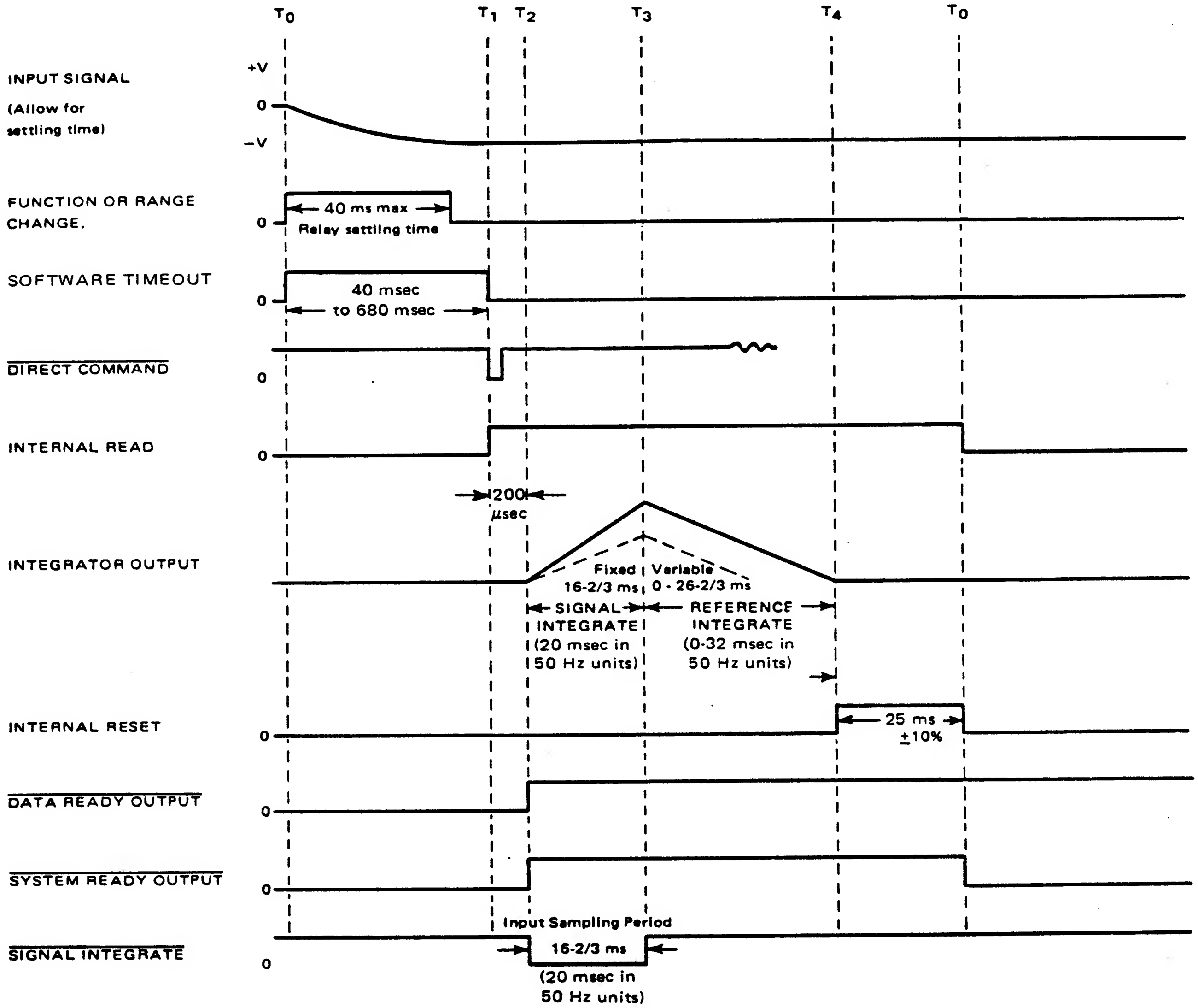


Figure 3.18A - Measurement Sequence with Timeout Command



NOTE: Data is not updated following this sequence unless a reading is commanded.

Except as noted:
Pulses are the same for 50 & 60 Hz

Figure 3.18B - Timing Sequence, Range or Function Change, No External Command

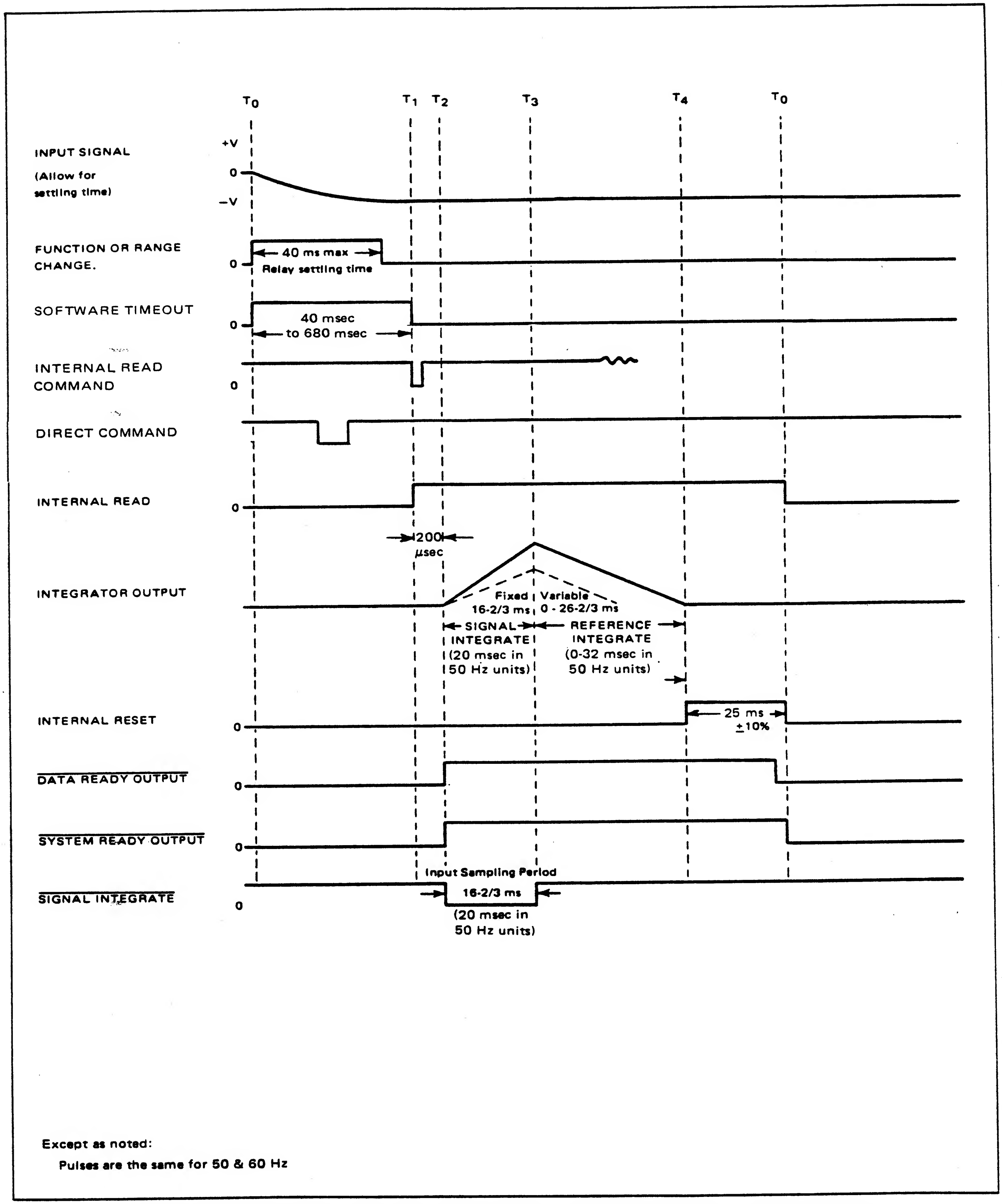


Figure 3.18C - Measurement Sequence, External Direct Command with Range or Function Change

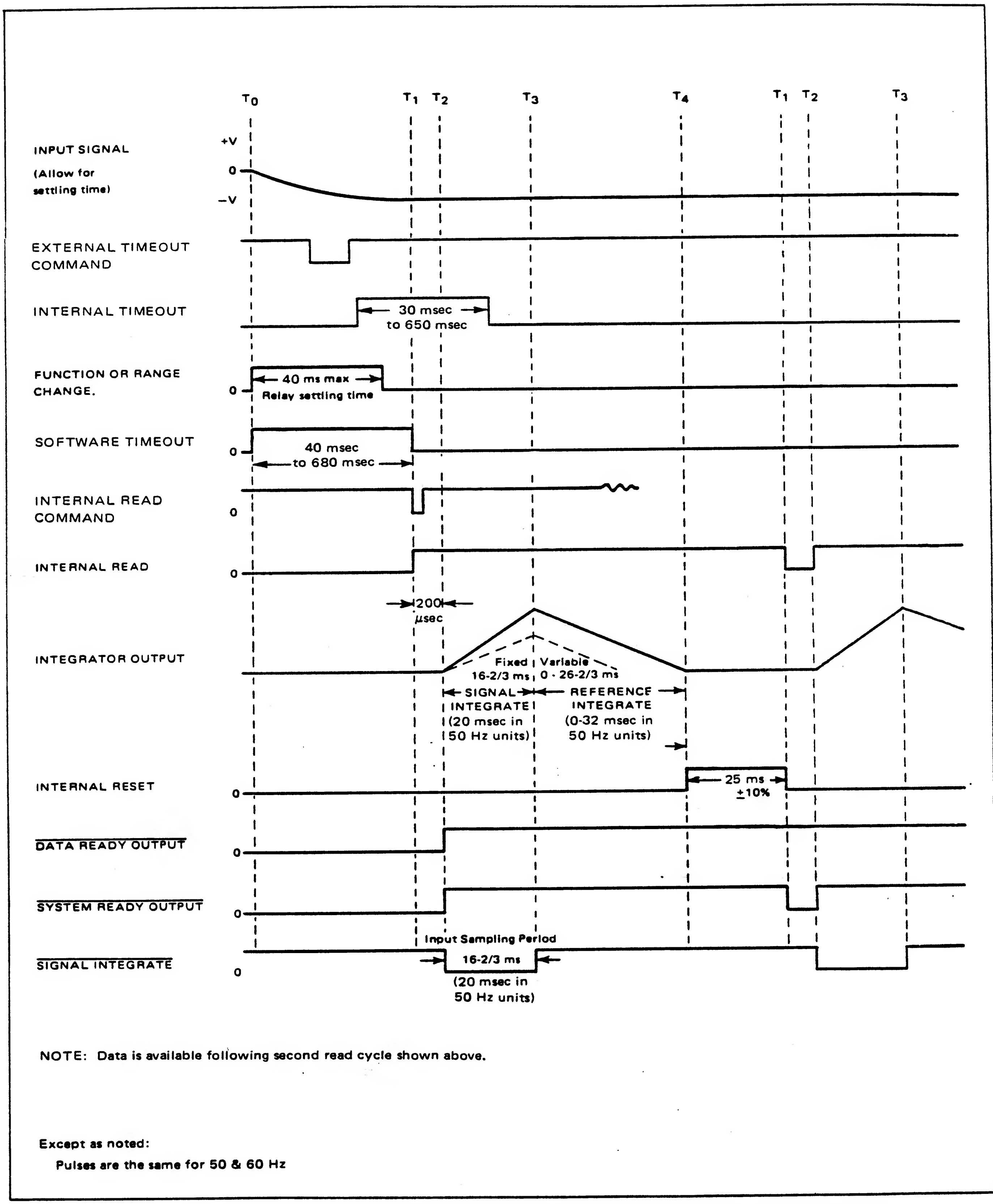
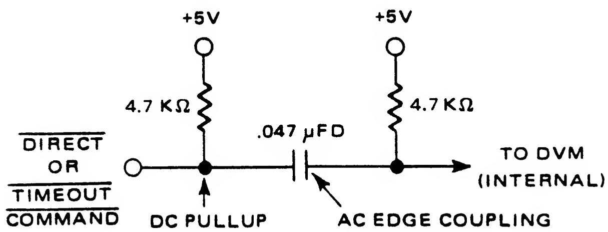


Figure 3.18D - Measurement Sequence, External Timeout Command with Range or Function Change

c. The Direct and Time Out Commands are AC coupled with pull-up resistors to +5 volts. These inputs are compatible with TTL outputs or contact closures to ground. The AC coupling does require that rise and fall times be less than 100 μseconds. This input circuit is illustrated below:



d. Digital output common can be floated as high as 200 VDC above power line ground.

3.5.4.7 TTL OUTPUT CAPABILITIES.

3.5.4.7.1 The 6000 electrical outputs are specified to drive two TTL inputs such as described in the TTL loading section. Summary:

False: 0 to +0.4V
True: +2.4 to +5.0V
Fan out: 2 minimum
Maximum Capacitance Load: 500 pF

3.5.4.8 TIMING SEQUENCE.

3.5.4.8.1 The standard remote mode of operation of the 6000 is to initiate a reading sequence with each Direct Command received through the programmer, providing that sufficient time has been allowed between commands for the reading to be completed. This reading sequence is illustrated in Figure 3.18.

$T_1 - T_0$ During this period the input signal must finish settling to within the desired accuracy. Any control changes involving the 40 msec relay settling time (a) can be completed; other logic control inputs (b) can also be changed.

$T_2 - T_1$ The Direct Command signal, which is AC coupled, must meet the following conditions:

a. Rise and fall times less than 100 μsec.

$T_3 - T_2$ The period of signal integration lasts for 16-2/3 msec (60 Hz line frequency; 20 msec in 50 Hz units). During this time the integrator charges to a voltage proportional to the input voltage. This is the input sampling period.

$T_4 - T_3$ During this period, the integrator is isolated from the input signal, and is discharged at a precise current. The time the integrator requires to discharge to a level equal to its voltage at T_2 is proportional to the input voltage. This time is measured by an internal counter and stored.

$T_0 - T_4$ This 15 mseconds (± 10%) is required for the microprocessor to calculate the actual reading.

$T_1 - T_0$ If the next read command is a Direct Command, this period must be made long enough to allow for the condition covered in the first cycle; however, if the next command is a Timeout Command, this period can approach zero since the necessary timeout to satisfy these conditions are automatically programmed.

3.5.4.9 OTHER READ COMMAND OPTIONS.

3.5.4.9.1 In addition to the Direct Command, there are two other programmable read commands, as illustrated in Figure 3.18.

a. Time Out Command: Again, this is an AC coupled input which must have rise and fall times of less than 100 μseconds but must remain in a "0" state for at least 0.1 μsecond. The timeouts given in Table 3.19 for various combinations of ranges and functions ranging from 30 mseconds to 500 mseconds will be automatically inserted before the internal read command is generated. If this command is wired to the System Ready Output on J212-pin 43, fully automatic reading with timeouts is achieved.

NOTE

The internal delay is not adequate for settling time on the 100 VDC, 1000 KΩ, 10 MΩ, 100 MΩ ranges, or any AC range. Therefore, the timeout command, providing timeout delays listed in table 3.19, must be used to initiate accurate readings on these ranges unless a fixed range and function have been programmed and the input has been present longer than the timeout period.

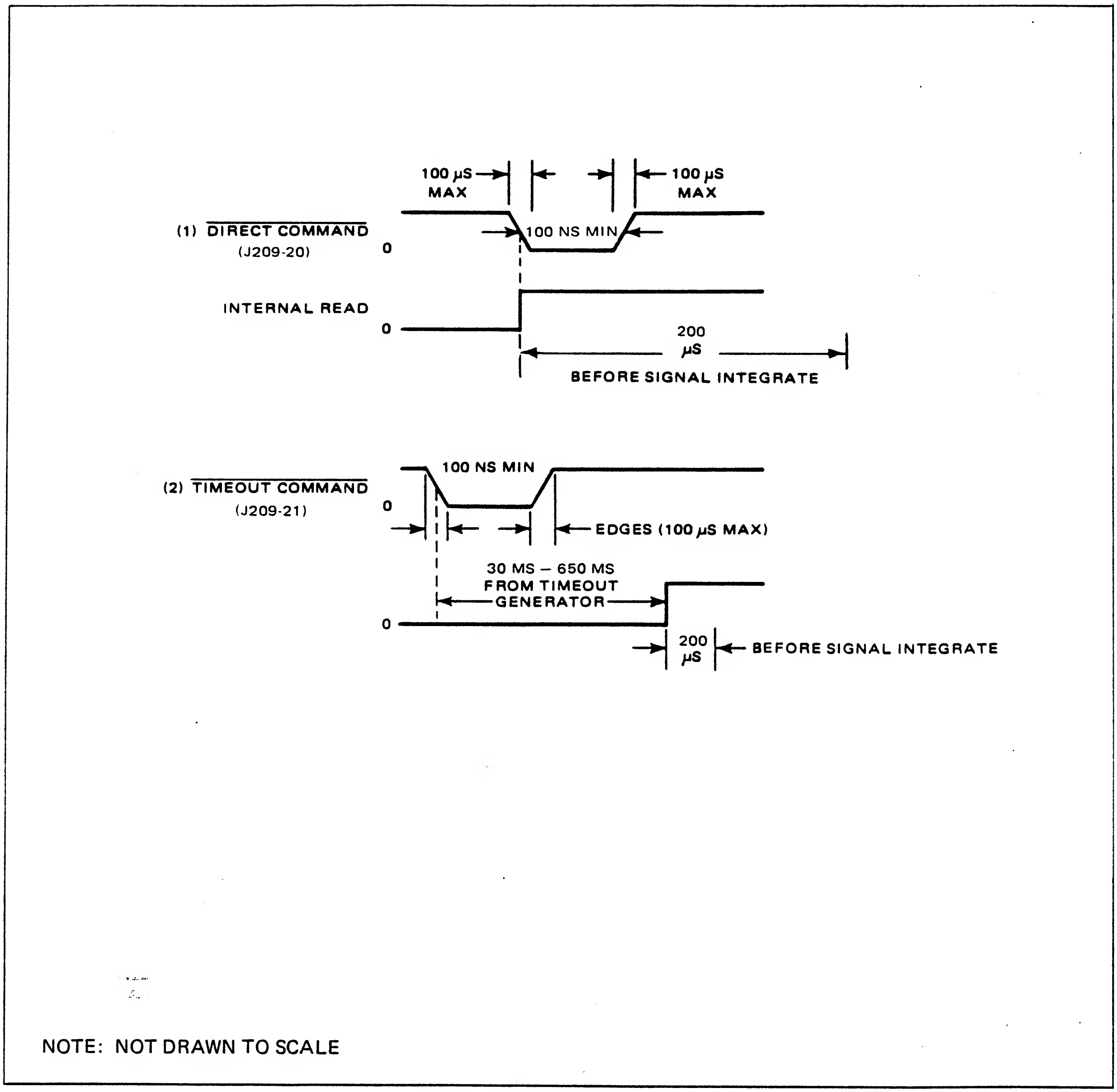
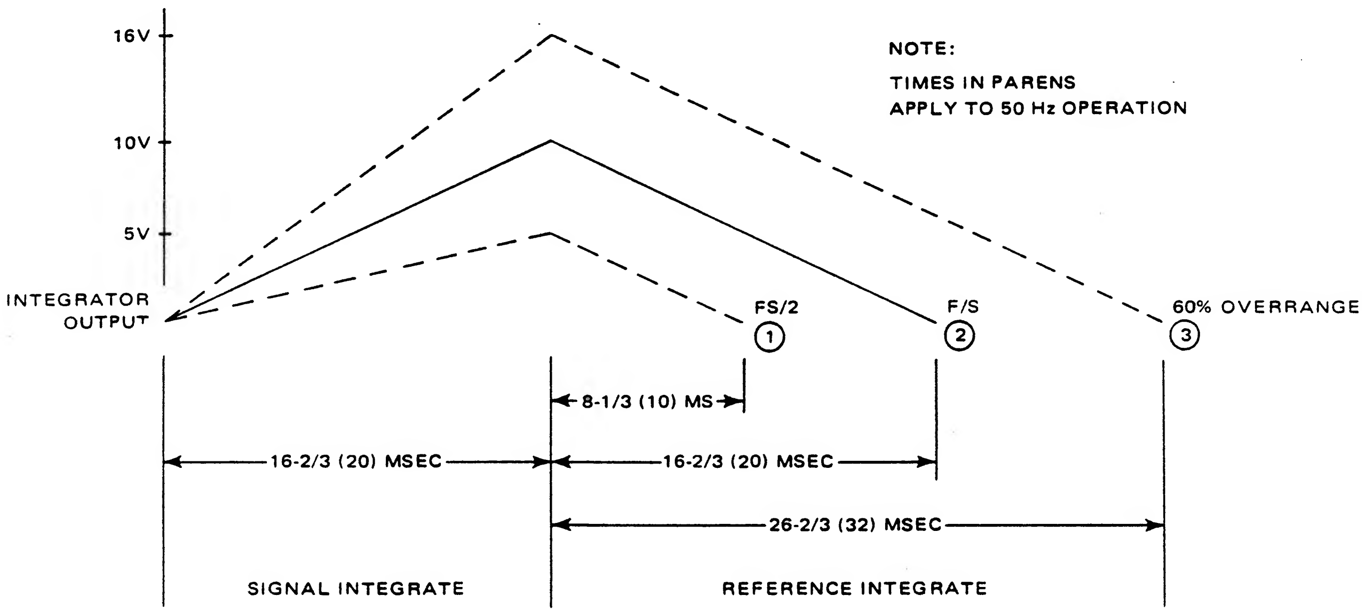


Figure 3.19 - Command Timing



READ RATES CORRESPONDING TO INTEGRATION PERIODS (ABOVE).

① V_{IN} = 5 VOLTS (HALF SCALE ON 10V RANGE)

50 Hz: $\frac{1000}{20 \text{ MS} + 10 \text{ MS} + 25 \text{ MSEC}}$ = 18.2 READINGS/SEC

60 Hz: $\frac{1000}{16\text{-}2/3 \text{ MS} + 8\text{-}1/3 \text{ MS} + 25 \text{ MS}}$ = 20.0 READINGS/SEC

② V_{IN} = 10V (FULL SCALE ON 10V RANGE)

50 Hz: $\frac{1000}{20 \text{ MS} + 20 \text{ MS} + 25 \text{ MS}}$ = 15.4 READINGS/SEC

60 Hz: $\frac{1000}{16\text{-}2/3 \text{ MS} + 16\text{-}2/3 \text{ MS} + 25 \text{ MS}}$ = 17.24 READINGS/SEC

③ V_{IN} = 16V (FULL SCALE & MAX. OVERRANGE) ON 10V RANGE:

50 Hz: $\frac{1000}{20 \text{ MS} + 32 \text{ MS} + 25 \text{ MS}}$ = 13 READINGS/SEC

60 Hz: $\frac{1000}{16\text{-}2/3 \text{ MS} + 26\text{-}2/3 \text{ MS} + 25 \text{ MS}}$ = 14.6 READINGS/SEC

Figure 3.20 - Read Rate vs. Input

3.5.4.10 READING RATES.

3.5.4.10.1 In Figure 3.20, integrator operation with three different input signal levels is illustrated: half scale, full scale, and 160% of full scale (full scale is defined as 100000 on any range). The figure shows that the maximum reading rate is a function of the input signal. The signal integrate period and internal reset remain fixed while the reference integrate period can vary from 0 to 32 mseconds. Therefore the maximum read rate could vary from 14.9 to 31.6 reading per second.

3.5.4.11 SUPERFAST.

3.5.4.11.1 The Superfast reading mode (programmed through either the PRINTER OUT or PROGRAM INPUT

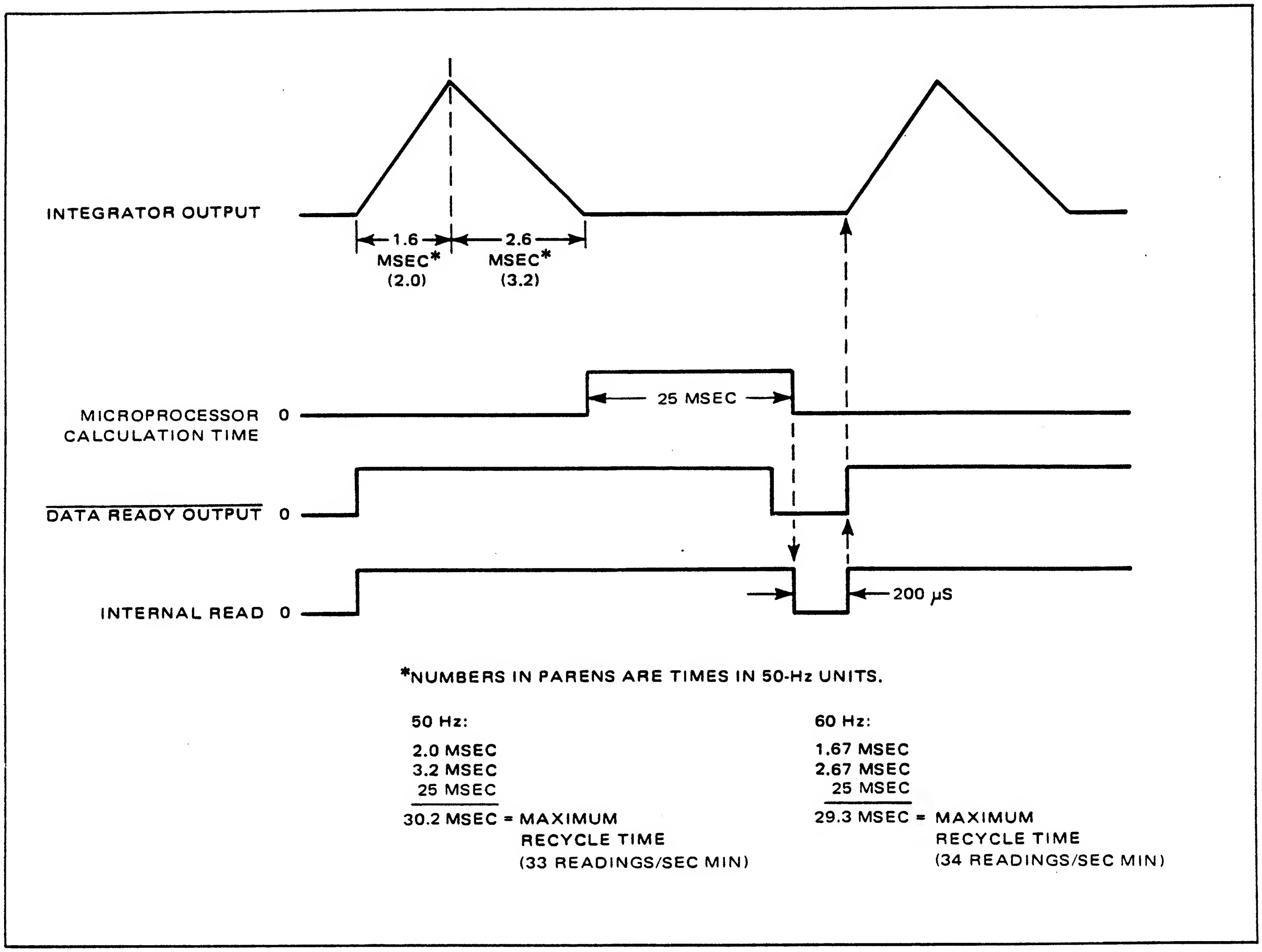


Figure 3.21 - Superfast Read Rate (Worst Case)

connector) increases the minimum reading rate from 14.6 to 34 readings per second (50 Hz: 13 to 33 r/s). This is done at the expense of losing the least-significant digit which is reset to zero (blanked out on readout). The signal integration period is reduced from 16-2/3 msec to 1-2/3 msec (50 Hz: 20 msec to 2 msec). This and the resulting reference integrate period reduce the maximum recycle time from 68.3 msec to 29.3 msec (50 Hz: 77 msec to 30.2 msec), thereby yielding the 34 reading per second figure (33 r/s with 50 Hz). Timing changes are shown in Figure 3.20.

3.5.5 Printer Output.

3.5.5.1 The printer output connector is a 3M type D 50 pin connector. Pin assignments are shown in Table 3.14. All outputs are referenced to digital ground pin 22.

3.5.5.2 NUMERICAL DATA.

3.5.5.2.1 Numerical data appears as positive true, four-line BCD code, as shown in Figure 3.15. The designator of each line identifies the digit and weight. For example: Pins 30, 29, 28, and 27 are designated 1_2, 1_8, 1_4, and 1_1 consecutively. The 1 indicates these lines correspond to the units or least significant display; the 2, 8, 4, and 1 subscripts indicate the binary weight of each line.

CAUTION

True output lines are not short-circuit proof. Accidental grounding may damage the output circuitry.

Table 3.14 - Pin Assignments J201 (Printer Output)

J212 Pin No.	Data Out
47	AC
46	Ratio
45	DC
44	Hold (Flag)
43	$\overline{\text{System Ready Out}}$
42	$\overline{\text{Super Fast In}}$
41	$\overline{\text{Data Disable In}}$
39	+ Polarity
38	– Polarity
37	$\overline{\text{Data Ready Out}}$
36	No
34	Rng D8
33	Rng A1
32	Rng C4
31	Rng B2
30	12
29	18
28	14
27	11
26	102
1	108
2	101
3	104
4	1002
5	1008
6	1001
7	1004
8	1K2
9	1K8
10	1K1
11	1K4
12	$\overline{\text{Signal Int}}$
13	10K2
14	10K8
15	100K1
16	10K11
17	10K1
18	Filter
19	System Control (Flag)
20	+5V
21	Ohms
22	Digital Gnd

3.5.5.2.2 Polarity is indicated in positive true format on pin 39 (positive) and pin 38 (negative). The positive polarity line is true when the function output is AC or ohms. If the instrument overranges, the polarity bit is not updated since no axis-crossing has occurred.

3.5.5.3 FUNCTION DATA.

3.5.5.3.1 Function outputs appear on pins 45, 46, 47 and 21 in their true format. For example: with AC function selected, AC is true and is indicated by a true level on the corresponding line.

3.5.5.4 RANGE DATA.

3.5.5.4.1 Range data appears in four-line BCD code on pins 31 through 34. Range codes are described in Table 3.15.

3.5.5.5 "NO" INDICATION.

3.5.5.5.1 The NO line (pin A12) is the same as the NO indicator on the readout. The line is true if a function or range is selected for which the particular instrument is not equipped. Overrange is indicated by a true NO line plus 'OL' on the display.

3.5.5.6 STATUS OUTPUT LINES.

3.5.5.6.1 The following outputs indicate the status of the conversion process within the instrument.

a. $\overline{\text{DATA READY}}$. This line (pin 37) remains true during the signal and reference integration periods plus any overrange time and microprocessor calculation time, if required. The line drops to the false level to indicate to the printer that the measurement is complete and output data can be printed (Printer Command). Minimum false level time is 2 mseconds.

b. HOLD FLAG. A true level on this line (pin 44) indicates that the instrument is in the Hold mode. A reading can be initiated by one of the following commands:

1. $\overline{\text{DIRECT COMMAND}}$ (J209-20)

2. $\overline{\text{TIMEOUT COMMAND}}$ (J209-21)

Table 3.15 - **Range Codes (Printer Output)**

Range	A (J212-33)	B (J212-31)	C (J212-32)	D (J212-34)	Dec Value
10Ω	0	1	0	0	2
0.1V 0.1 KΩ	1	1	0	0	3
1V 1 KΩ	0	0	1	0	4
10V 10 KΩ	1	0	1	0	5
100V 100 KΩ	0	1	1	0	6
1000V 1000 KΩ	1	1	1	0	7
10 MegΩ	0	0	0	1	8
100 MegΩ	1	0	0	1	9

c. SYSTEM READY. This line (pin J212-43) drops to a false level to indicate that the instrument can now initiate a new reading at the first available read command.

d. SIGNAL INTEGRATE. This line (pin J212-12) becomes true at the end of the signal integration period. After this time, the input signals may be changed in preparation for the next reading. The input signal need remain constant only while the instrument is in Signal Integrate, indicated by this line in the false state. For example, the 1-2/3 msec sample time in Superfast could be used in slow sample and hold applications.

3.5.5.7 INPUT CONTROL LINES.

a. DATA DISABLE. A contact closure to ground or a false logic level applied to this line (J212-41) inhibits the DATA READY output (Print) pulse.

b. SYSTEM CONTROL. A contact closure to ground or a false logic level on this line (J209-16) disables all front panel operating controls, except 'Shift' and 'Local'. Operation of the instrument is then under control of the Remote Program input. This command duplicates operation of the 'Shift' 'Local' switch on the front panel. 'Shift' 'Local' switch can be pressed from the front panel to operate the system under the control of program input. 'Shift' 'Local' is used in toggle mode - by pressing the keys again system will be in local mode.

c. SUPERFAST. A contact closure to ground or a false logic level applied to this line (J212-42 or J209-15) decreases the conversion time of the instrument while sacrificing the least-significant digit. This mode is described in paragraph 3.5.4.11. Because of the superfast read rate, do not use this mode with Autorange.

3.5.6 Remote Programming.

3.5.6.1 The instrument accepts commands made through **PROGRAM INPUT** connector J209 on the rear panel. Pin assignments of J209 are shown in Table 3.16. Commands

Table 3.16 - Pin Assignments J209 (Program Input)

J209 Pin No.	Data Out
1	A1
2	C4
3	B2
4	D8
5	Hold
6	AC
7	Ohm
8	Filter
9	Ratio
14	Data Inhibit
15	Superfast
16	System Control
17	+5V
18	Program Storage
19	Digital Ground
20	Direct Command
21	Timeout Command
22	Auto Cal

Table 3.17 - **Function Programming**

$\overline{DC}$	NC
$\overline{AC}$	J209-6
$\overline{OHMS}$	J209-7
$\overline{RATIO}$	J209-9
$\overline{FILTER}$	J209-8

are made by a switch closure from the appropriate pin to ground or by low power schottky TTL logic levels as described earlier.

3.5.6.2 SYSTEM CONTROL.

3.5.6.2.1 A contact closure to ground or a false logic level applied to pin J209-16 disables all front panel operating controls, except 'Shift' and 'Local'. Operation of the instrument is then under control of the remote program input. This line duplicates the 'Shift' 'Local' switch on the front panel.

3.5.6.3 FUNCTION PROGRAMMING.

3.5.6.3.1 The desired function is selected by applying a ground or false logic level to the appropriate pin (Table 3.17).

3.5.6.3.2 The internal delay is not adequate for settling time on the 100 VDC, 1000 Kilohm, 10 Megohm, 100 Megohm, and all AC ranges. Therefore, the timeout command, providing timeout delays listed in Table 3.19, must be used to initiate readings on these ranges unless the input is fixed with range and function predetermined.

3.5.6.4 RANGE PROGRAMMING.

3.5.6.4.1 Range programming is selected by applying false logic levels in BCD code to the four range lines described in Table 3.18. With no lines programmed, Autorange is automatically selected.

Table 3.19 - **Timeouts**

DC	40 msec
1 Ohm to 1 Megohm	40 msec
10 Meg*	40 msec
100 Megohm	400 msec
Filter	630 msec (plus function timeout)
AC(fixed range, no filter)	240 msec
AC+Filter(&Autorange)	860 msec
*Use filter for <.01% error	

3.5.6.5 + FIVE VOLTS.

3.5.6.5.1 This voltage, +5 volts ± 5%, from the logic power supply is available at pin J209-17 for external use. Current output is .1A, maximum.

3.5.6.6 HOLD.

3.5.6.6.1 The Hold line is selected by a contact closure or a false logic level on pin J209-5. Hold is required when using either of the three read commands.

3.5.6.6.2 With the Hold line selected, changing the Function or Range function generates an internal reading. The System Ready output is directly set or reset by the Signal Integrate line as shown in Figure 3.22. If System Ready Output is used to generate readings, it will create a valid reading after the Function or Range is changed.

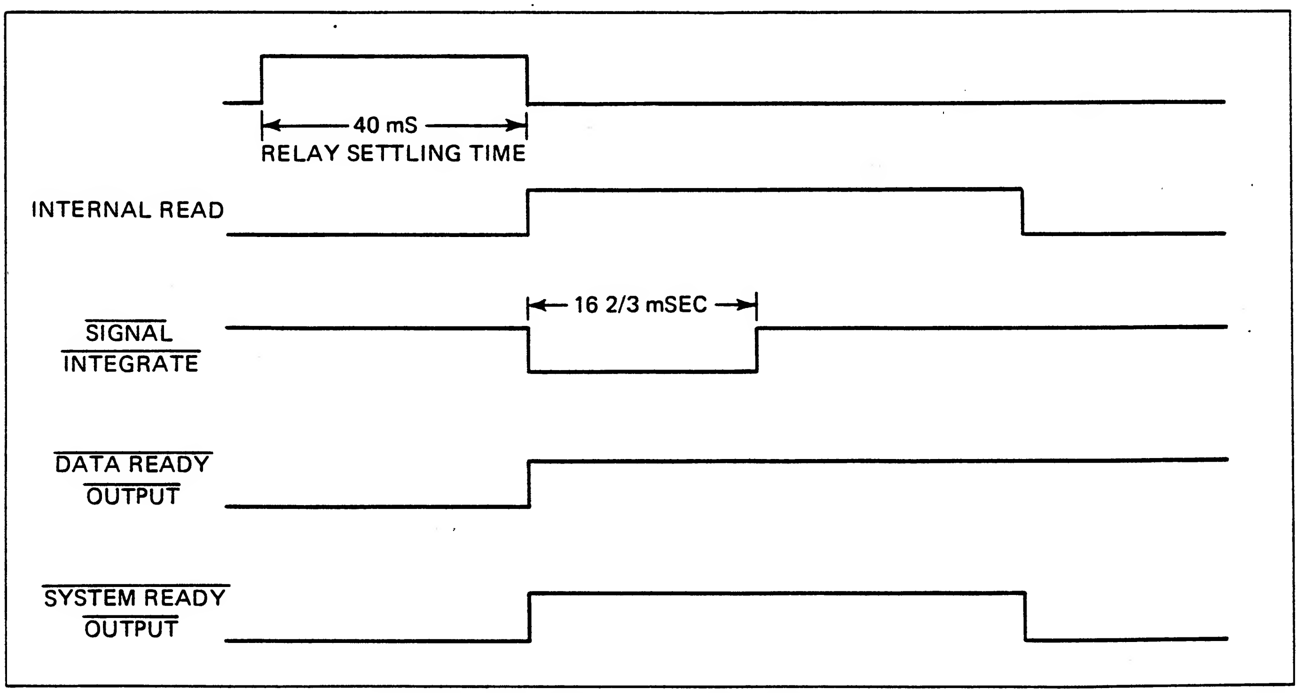


Figure 3.22 - Internally Generated Timing Chart

Table 3.18 - Range Codes (Programmer)

Range	$\overline{A}$ (J209-1)	$\overline{B}$ (J209-3)	$\overline{C}$ (J209-2)	$\overline{D}$ (J209-4)	Dec Value
AUTO	1	1	1	1	0
10Ω	1	0	1	1	2
0.1V 0.1 KΩ	0	0	1	1	3
1V 1 KΩ	1	1	0	1	4
10V 10 KΩ	0	1	0	1	5
100V 100 KΩ	1	0	0	1	6
1000V 1000 KΩ	0	0	0	1	7
10 MegΩ	1	1	1	0	8
100 MegΩ	0	1	1	0	9

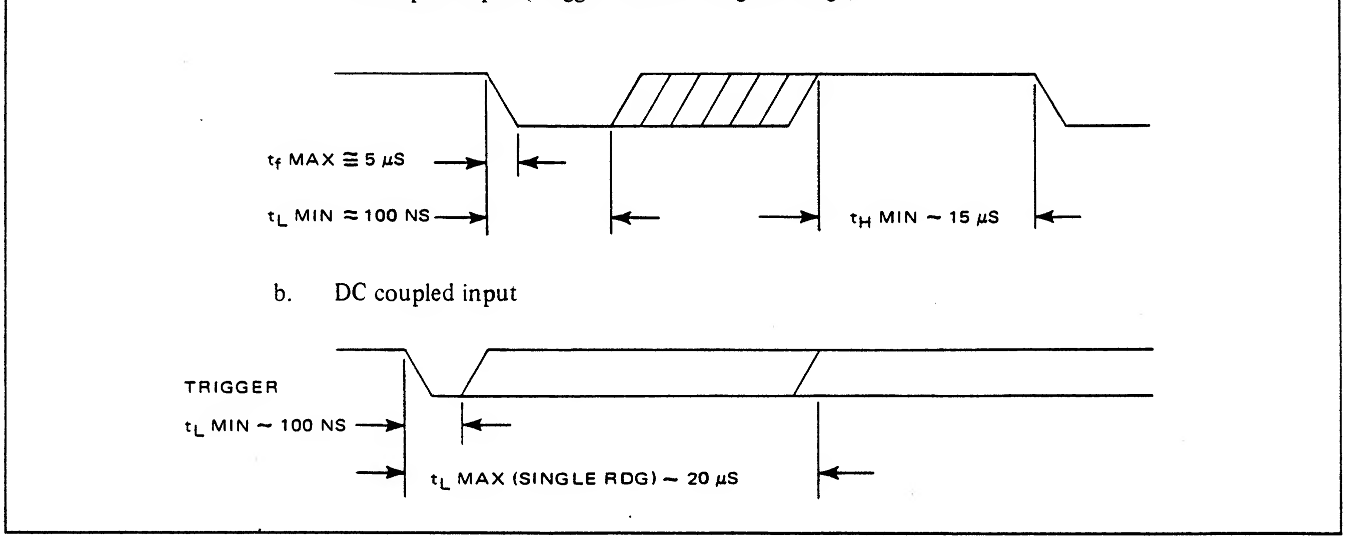


Figure 3.23 - Trigger Waveform

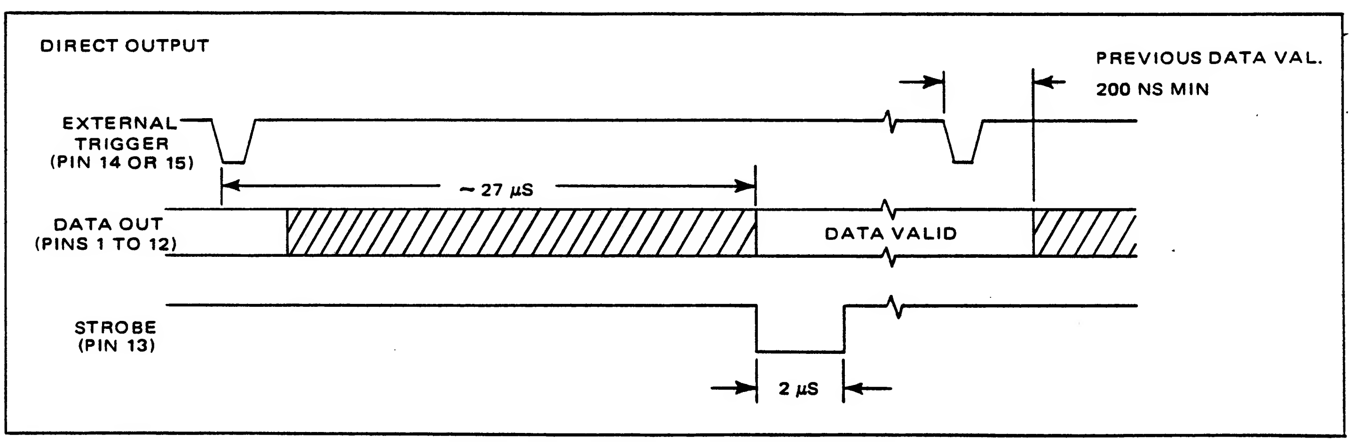


Figure 3.24 - Option 03 Output Waveforms

3.5.6.7 READ COMMANDS.

3.5.6.7.1 Either of two read command lines can be selected by a contact closure to ground or by a negative logic level applied to the appropriate pin. J209-20. $\overline{\text{DIRECT}}$ $\overline{\text{COMMAND}}$, commands a new measurement if applied after fifteen millisecond delay, and if the command is present for .1 µseconds. Pin J209-21, $\overline{\text{TIMEOUT COMMAND}}$, starts a new measurement after fifteen milliseconds plus a

Table 3.20 - Maximum Input Voltage

CAUTION Do not exceed the following maximum inputs.	
DC	1000 VDC or RMS AC All ranges
AC	1000 RMS to 15 kHz decreasing 20 dB/ decade to 15V RMS at 1 MHz
RATIO	Input: DC/DC hardware ratio Reference: +10.5V, +1 VDC
OHMS	±500V DC or Peak AC
GUARD	Voltage between GUARD AND – INPUT must not exceed 250 volts or damage to the instrument may result

timeout delay to allow for internal settling time of the measured signal. TIMEOUT COMMAND cannot be commanded before the previous 25 msec delay.
generator stores the reading.

3.5.6.8 TIMEOUTS.

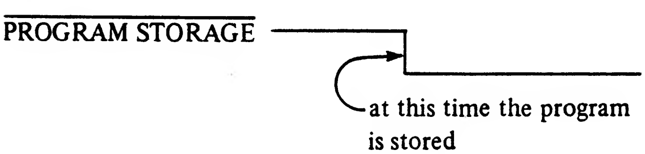
3.5.6.8.1 Timeout periods for each function are listed in table 3.19. In Autorange, the indicated delays are taken following each range change.

3.5.6.9 DATA INHIBIT.

3.5.6.9.1 A contact closure or false logic level on pin J209-14 inhibits DATA READY OUTPUT (Print pulse) from being generated.

3.5.6.10 PROGRAM STORAGE.

3.5.6.10.1 A false level (equivalent to three TTL inputs) on pin J209-18 will store all the programmed inputs except the Direct and Timeout commands and Auto-Cal as they existed on the negative edge of this command (see diagram below.



3.5.6.11 SUPERFAST.

3.5.6.11.1 A contact closure to ground or a false logic level applied to pin J209-15 decreases the signal integrate and the reference integrate times (see paragraph 3.5.4.11). This provides the maximum reading rate in the DIRECT COMMAND mode of operation. Because of the high reading rate, Superfast must be programmed with a fixed range rather than Autorange.

3.5.6.12 AUTO CALIBRATION.

3.5.6.12.1 A contact closure to ground or false logic level on this line will initiate the auto calibration procedure and the system will go through complete calibration. If this input is held low, it will disable auto calibration. If this input is not held low, it will go through the auto calibration programmed by main program.

3.6 FAST A/D (OPTIONS 03 AND 03 SH).

3.6.1 These options provide for high speed digitizing of analog waveforms.

3.6.2 The Fast A/D may be controlled through the keyboard, via the GPIB or through its interface connector (Figure 2.2) located on the rear panel.

3.6.3 The Fast A/D may be triggered at rates up to 30 KHz. The maximum read rate is, however, limited to 250 readings per second when the output data is to be read from the 6000 display or 6000 readings per second when the GPIB is used. The full conversion speed is available only when the data is transmitted via its interface connector. The conversion time will be less than 29 μsec for all modes.

3.6.4 Two mutually exclusive trigger inputs are available, AC coupled and DC coupled. Figure 3.23 shows the required waveforms.

3.6.5 The direct output provided from the rear panel is in binary 2's complement format. Each output can drive 2 TTL loads. The output is scaled to +20.47 and –20.48 volts full scale. Thus, octal 3777 indicates +20.47V while octal –3777 indicates –20.47V.

3.6.6 Output waveforms for Option 03 are shown in Figure 3.24 and output waveforms for Option 03SH are shown in Figure 3.25. The GPIB data word format is the same for both Options 03 and 03SH (reference Figure 3.27). Table 3.21 provides an input voltage to octal data to binary data conversion. The octal data is displayed on the 6000 readout when the display is enabled. The binary data is outputted from the rear panel Fast A/D or Sample and Hold Fast A/D connector.

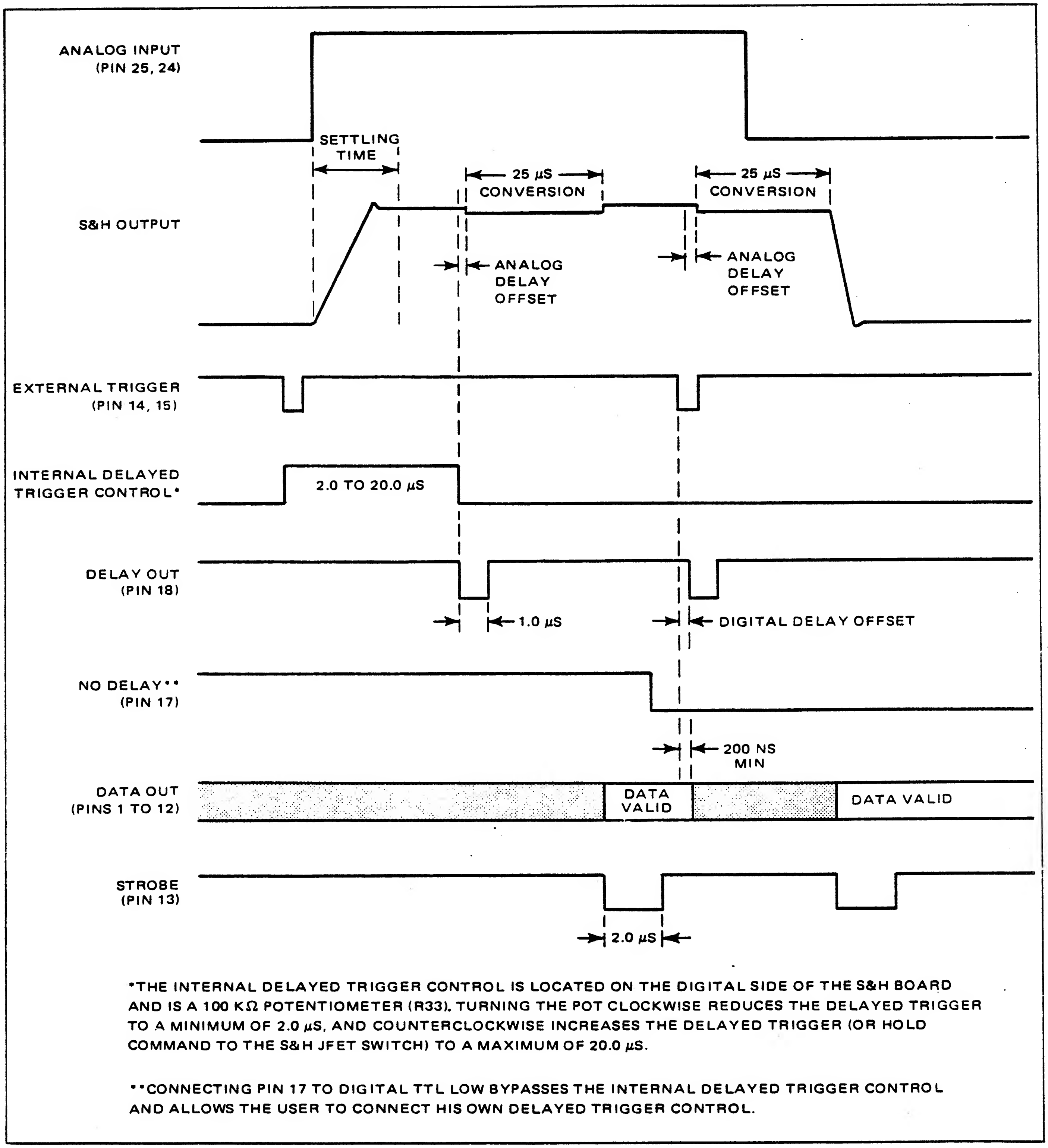


Figure 3.25 - Option 03 SH Output Waveforms

3.6.7 Sample and Hold Fast A/D (Option 03SH).

3.6.7.1 The sample and hold version of the Fast A/D (Option 03SH) may be added to the Model 6000 for applications requiring precise timing of measurements or very short sample times. The sample and hold circuitry increases the data bandwidth of the Fast A/D, and allows for the digitizing of selected portions of input waveforms. Option 03SH also provides an adjustable delay circuit that delays the aperture point to compensate for system settling time. Figure 3.26 shows a programming model of the 03SH converter.

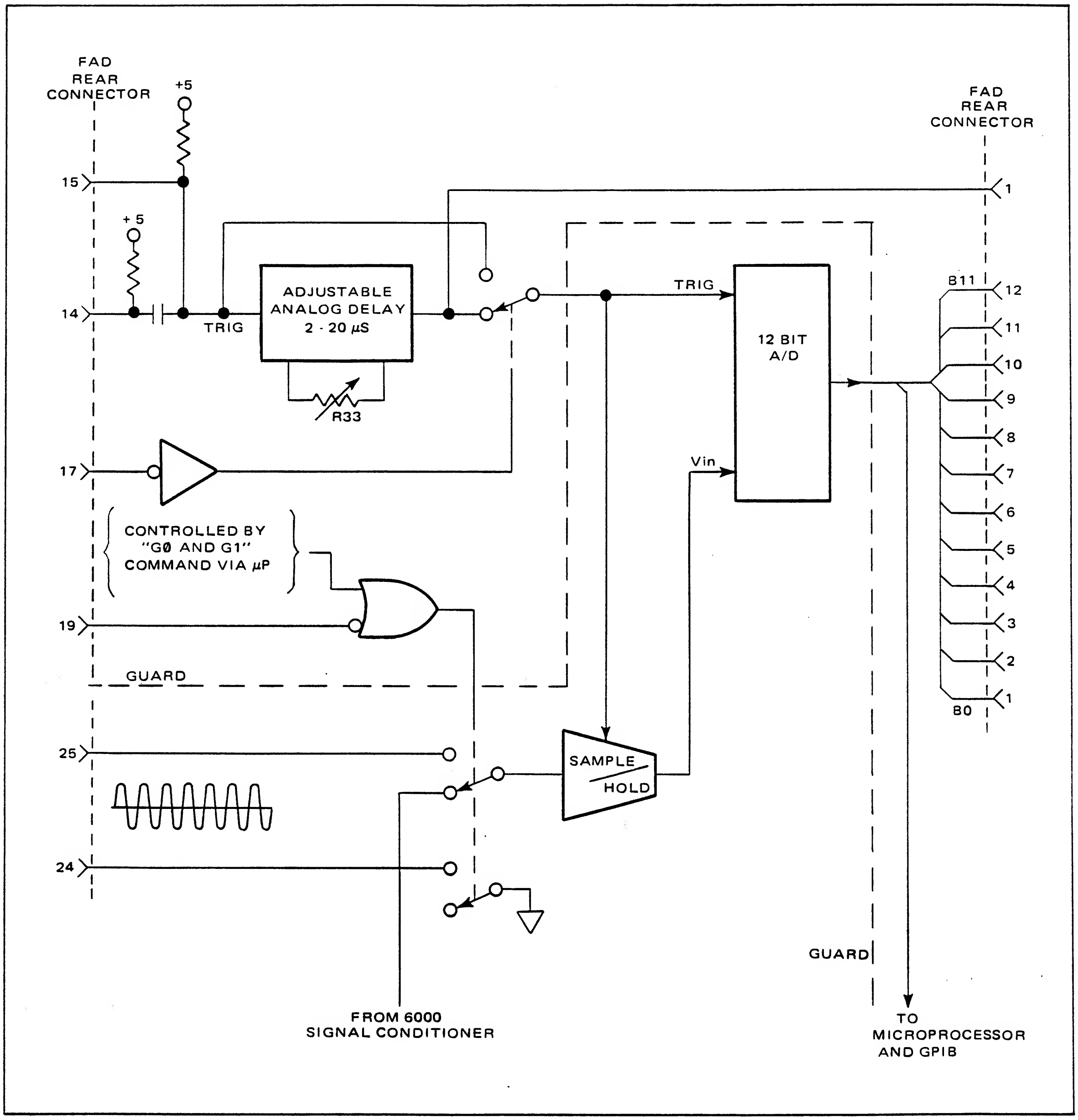


Figure 3.26 - Programming Model For Option 03-S/H

	D10₈						D10₁
BYTE #1	1	*	MSB	•	•	•	•	2^6
BYTE #2	0	*	2^5	•	•	•	•	LSB

*See GPIB Text

Figure 3.27 - GPIB Data Output Format (Options 03 and 03 SH)

Table 3.21 - Fast A/D Output Data Conversion Reference (Option 03 & 03SH)

NOTE: The scale factor for the Fast A/D is 1 count (octal or binary) per 10mV of input voltage.

Voltage Input	Octal Display*	Binary Output*
−20.480	−3777**	100 000 000 000
−20.470	−3777	100 000 000 001
−20.000	−3720	100 000 110 000
−19.000	−3554	100 010 010 100
−18.000	−3410	100 011 111 000
−17.000	−3244	100 101 011 100
−16.000	−3100	100 111 000 000
−15.000	−2734	101 000 100 100
−14.000	−2570	101 010 001 000
−13.000	−2424	101 011 101 100
−12.000	−2260	101 101 010 000
−11.000	−2114	101 110 110 100
−10.240	−2000	110 000 000 000
−10.000	−1750	110 000 011 000
−9.000	−1604	110 001 111 100
−8.000	−1440	110 011 100 000
−7.000	−1274	110 101 000 100
−6.000	−1130	110 110 101 000
−5.120	−1000	111 000 000 000
−5.000	−0764	111 000 001 100
−4.000	−0620	111 001 110 000
−3.000	−0454	111 011 010 100
−2.500	−0372	111 100 000 110
−2.000	−0310	111 100 111 000
−1.500	−0226	111 101 101 010
−1.000	−0144	111 110 011 100
−0.500	−0062	111 111 001 110

Voltage Input	Octal Display*	Binary Output*
−0.250	−0031	111 111 100 111
−0.010	−0001	111 111 111 111
0.000	0000	000 000 000 000
+0.500	0062	000 000 110 010
+1.000	0144	000 001 100 100
+1.500	0226	000 010 010 110
+2.000	0310	000 011 001 000
+2.500	0372	000 011 111 010
+3.000	0454	000 100 101 100
+4.000	0620	000 110 010 000
+5.000	0764	000 111 110 100
+5.110	1000	001 000 000 000
+6.000	1130	001 001 011 000
+7.000	1274	001 010 111 100
+8.000	1440	001 100 100 000
+9.000	1604	001 110 000 100
+10.000	1750	001 111 101 000
+10.230	2000	010 000 000 000
+11.000	2114	010 001 001 100
+12.000	2260	010 010 110 000
+13.000	2424	010 100 010 100
+14.000	2270	010 101 111 000
+15.000	2734	010 111 011 100
+16.000	3100	011 001 000 000
+17.000	3244	011 010 100 100
+18.000	3410	011 100 001 000
+19.000	3554	011 101 101 100
+20.000	3720	011 111 010 000
+20.470	3777	011 111 111 111

*The 12 bit data output (from the Fast A/D connector or the GPIB connector) is in two's complement. When the output information is displayed, the 12 bit data is presented (on the 6000 display) in signed octal format.

**Display cannot indicate greater than '3777'

3.7 CALIBRATION CHECK-SPECIFICATION VALIDATION

3.7.1 General.

3.7.1.2 This section contains procedures that compare the operation of the instrument against the published specifications found at the front of this manual. It is intended to be used for incoming inspection and as a periodic check to determine if recalibration of the instrument is warranted.

3.7.1.3 The procedures provide sufficient checks to verify proper operation and that the instrument is within the 90 day accuracy limits. Covers of the instrument are not removed for any of the tests. The required ambient temperature of the environment is $23^{\circ} \pm 5^{\circ}C$.

3.7.2 Required Equipment.

3.7.2.1 In Table 3.22 is a list of equipment necessary for checking the instrument. The equipment in this table, with the exception of those in the OTHER category, is the same as required for recalibration and is explained in detail in the following paragraphs.

3.7.2.2 The specific types of equipment in the Suggested Equipment column are acceptable for calibration and provided as a guide in selecting suitable equipment; instruments having operating characteristics equal to or better than those indicated may be substituted.

Table 3.22 - Required Equipment

Function	Qty	Item	Minimum Use Specifications	Suggested Equipment
DC	(1)	Saturated Standard Cell Bank (6 cells)	1 ppm, certified	EPPLEY 106
	(2)	DC Voltages Sources	0.1 ppm resolution	FLUKE 332B
	(2)	Voltage Divider, Adjustable	0.1 ppm linearity	FLUKE 720A
	(1)	10:1 Voltage Divider, Fixed	1 ppm, Output Z ≤10 Kohms	ESI RV622, With corrections
	(1)	100:1 Voltage Divider, Fixed	1 ppm, Output Z ≤10 Kohms	ESI RV622, With corrections
	(2)	Null Detector/μ Voltmeters	1 μV sensitivity	FLUKE 845AR
AC	(1)	Thermal Transfer Standard	50 ppm	HOLT 6A, With corrections
	(1)	AC Voltage Source	1 ppm resolution	HP745A/746A
Ω	(8)	Resistance Standards		
		10Ω	10 ppm	ESI SR1 with corrections
		100Ω	5 ppm	ESI SR1 with corrections
		1 KΩ	5 ppm	ESI SR1 with corrections
		10 KΩ	5 ppm	ESI SR1 with corrections
		100 KΩ	5 ppm	ESI SR1 with corrections
		1 MΩ	5 ppm	ESI SR1 with corrections
		10 MΩ	20 ppm	ESI SR1 with corrections
		100 MΩ	80 ppm	Fabricated
OTHER	(1)	Momentary Switch, SPST	–	–
	(2)	1.5 volt cells w/screwtype binding posts	–	–
	(1)	Insulated Adjustment tool	–	JFD5284
	(1)	100Ω, 10 Kilohm, 1 Megohm 1/4 Watt 5% Carbon Resistors	5%	–
	(1)	1 μFD non polar capacitor	–	–
	(1)	100MΩ, metal film resistor of known value	25 ppm	–

3.7.2.3 DC VOLTAGE SOURCES.

3.7.2.3.1 To produce voltage levels of necessary accuracy, special techniques are required. Suitable methods of generating these voltages are shown in Figures 3.28 and 3.29.

3.7.2.3.2 *10 Volt Source.*

3.7.2.3.2.1 A precise and traceable source of 10 volts is required, not only for calibrating the 10 volt range, but also as a reference for generating highly accurate .1, 1, 100, and 1000 volt levels. The 10 volt source used must satisfy the following requirements.

a. It must be traceable to the National Bureau of Standards;

b. It must have a total accuracy of 1.1 ppm;

c. It must have a low output impedance.

3.7.2.3.2.2 A source filling these requirements is shown in Figure 3.28. This circuit consists of a null detector, 7-decade voltage divider, a DC voltage supply, and a bank of saturated standard cells. Two advantages of this particular hookup are that; (a) there is minimal loading of the standard cells and (b) stability, not accuracy, is the primary requirement of the dc voltage supply.

3.7.2.3.2.3 The output of this circuit is set to a precise 10 volts by setting the voltage divider to the value of the standard cells. The DC voltage source is then adjusted to produce a null on the null detector. The accuracy of the 10 volt source is within 1.1 ppm.

3.7.2.3.3 *Other Sources.*

3.7.2.3.3.1 The remainder of the DC sources can be generated by the circuits shown in Figure 3.29. Each of these hookups use a calibrated 10 volt source having the characteristics of the one previously described.

3.7.2.3.4 *Accuracy, DC.*

3.7.2.3.4.1 The accuracy of the DC voltage sources is obtained by adding the various sources of error in each hookup; errors in this discussion are defined in parts per million (ppm). For the 10 volt source, the error is the sum of the standard cell bank (certified at 1 ppm) and the voltage divider (0.1 ppm), giving a constant 1.1 ppm. In Table 3.23 is shown the errors of each voltage source, the total accuracy of each hookup, the accuracy of the Model 6000 DMM, and the degree to which the sources exceed the required accuracy of the DMM (4 to 10 times better is the suggested accuracy ratio per MIL-M-38793).

Table 3.23 - DC Source Accuracies

Range	10 Volt Source	Fixed Divider	Total Accuracy	24 hr. DMM Full Scale Accuracy	Times Better
10	1.1 ppm	–	1.1 ppm	10 ppm	9
1	1.1 ppm	1 ppm	2.1 ppm	20 ppm	9.5
100 mV	1.1 ppm	1 ppm	2.1 ppm	70 ppm	33
100	1.1 ppm	1 ppm	2.12 ppm	20 ppm	9.5
1000	1.1 ppm	1 ppm	2.12 ppm	20 ppm	9.5

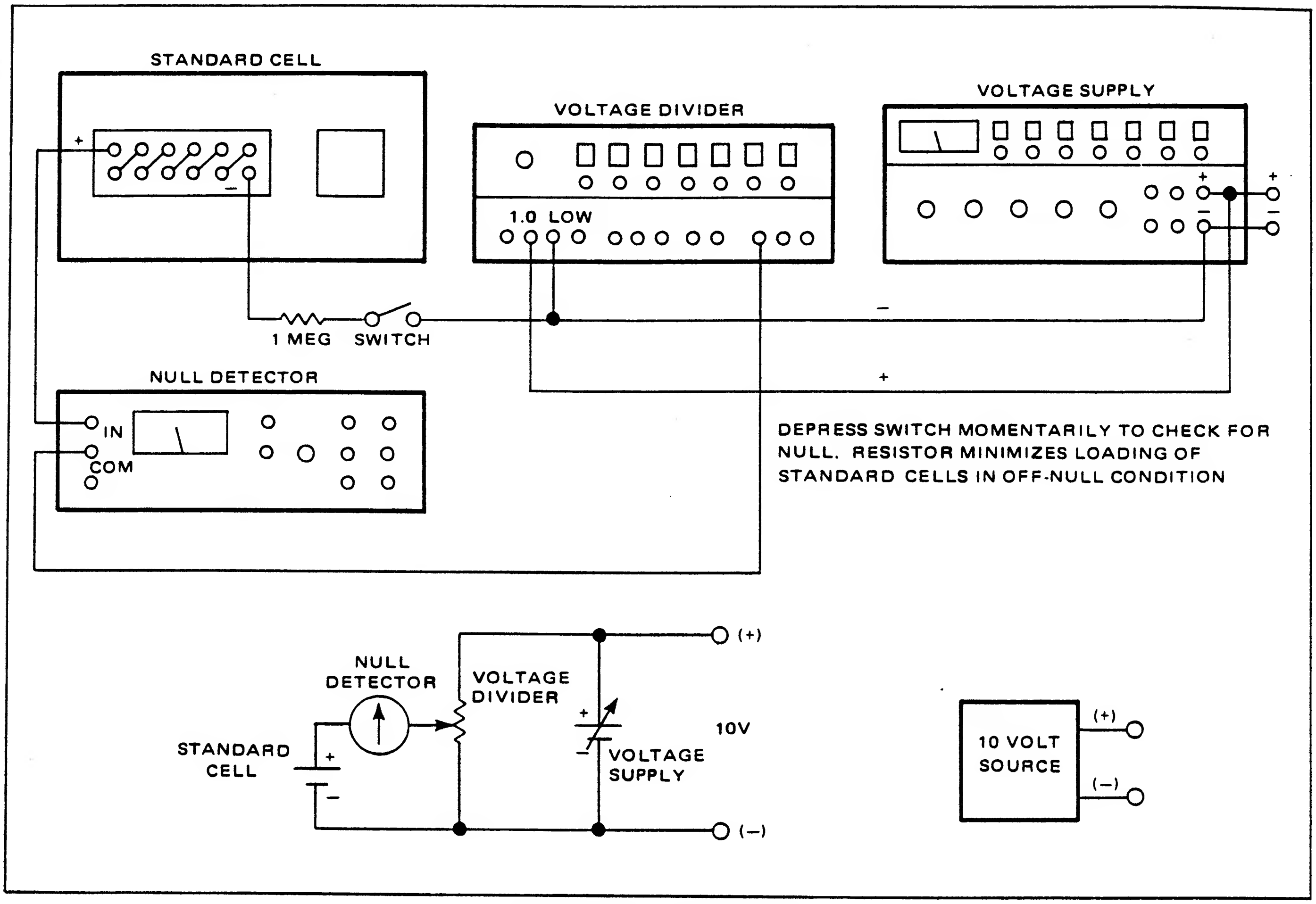


Figure 3.28 - 10 Volt Source

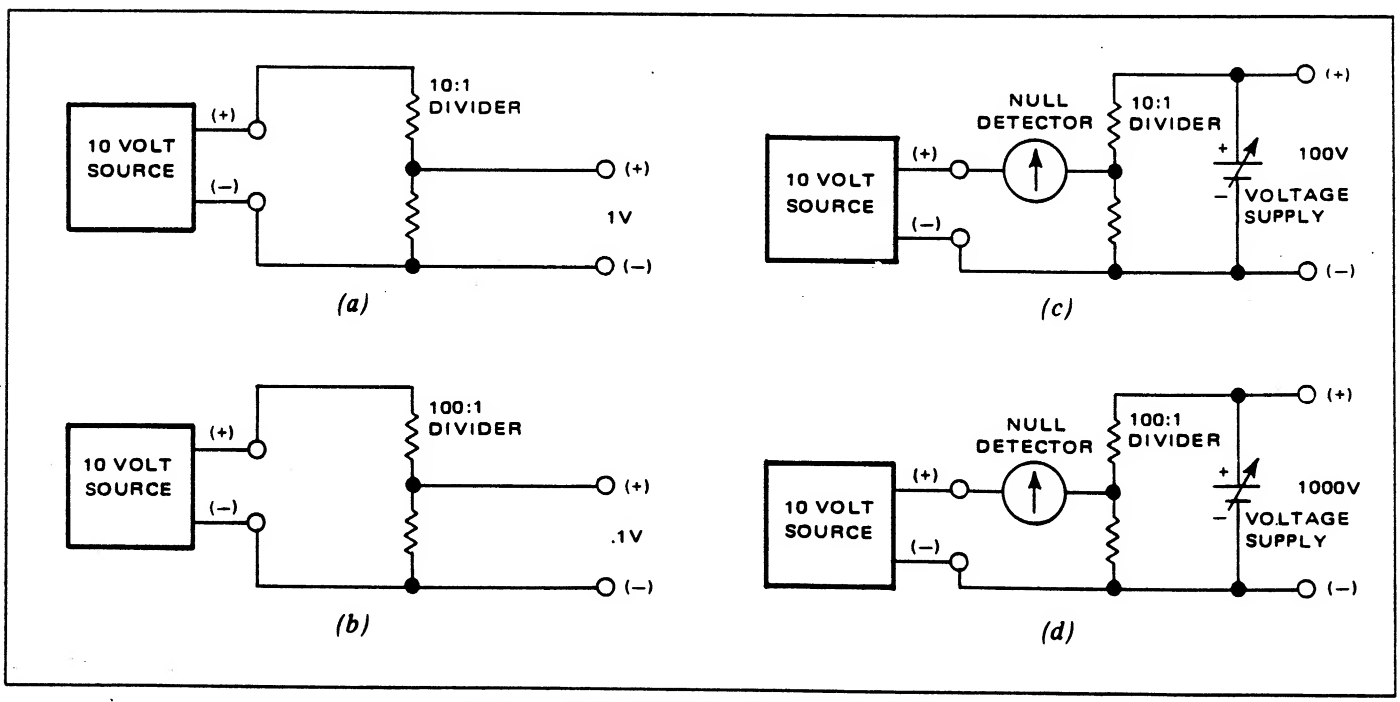
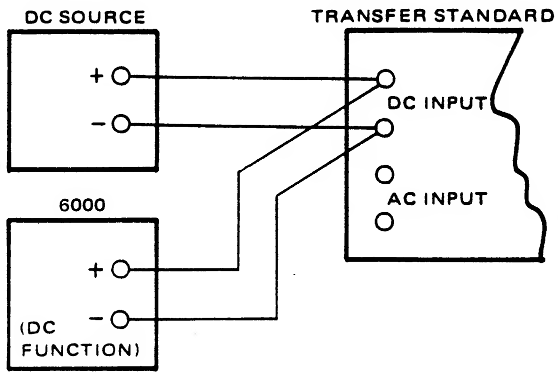
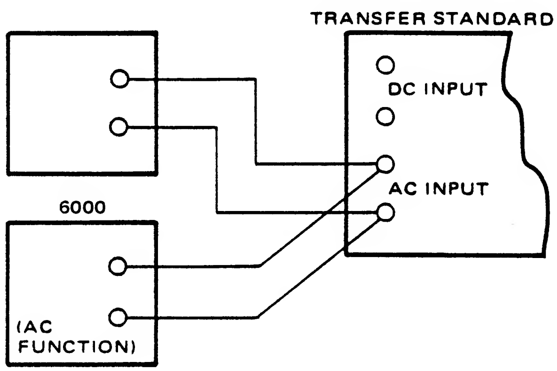


Figure 3.29 - Generating Accurate DC Levels



DC. With DMM used to monitor DC output, DC source is adjusted to desired voltage. Transfer standard is then used per manufacturer instructions.



AC. The ac source is adjusted to produce a null on transfer standard. The AC source output is now calibrated and can be used as a precision source for the recalibration of the 6000 AC Converter. (Option 10)
NOTE: **Because of the low input impedance of the transfer standard, the DMM input leads must be connected as close to the transfer standard input terminals as possible.**

Figure 3.30 - AC Source

3.7.2.4 AC VOLTAGE SOURCES.

3.7.2.4.1 The generation of accurate ac signals for checking the AC Converter ranges, requires the use of a thermal transfer standard and a precise DC standard as well as a stable AC source. Sufficient accuracy can be obtained by using a DC source and the Model 6000 being tested. The circuitry connections are shown in Figure 3.30. Information on the use of the transfer standard can be obtained from the operators manual accompanying the standard. The 6000 is used to set the DC source to the desired voltage; the thermal transfer standard is then used to calibrate the output of the AC source. The calibrated AC source is used to check the 6000 AC Converter. This procedure is repeated for each range.

Table 3.24 - AC Source Accuracies

INPUT		ACCURACY		
AC Source		Thermal Transfer Standard	DC Source	Total AC Source
Volts	Freq			
1, 10, and 100 Volts	400 Hz	35 ppm	10 ppm	45 ppm
	50 kHz	50 ppm		60 ppm
500 Volts	40 kHz	50 ppm		60 ppm
1000 Volts	400 Hz	52 ppm		62 ppm

3.7.2.4.2 *Accuracy, AC.*

3.7.2.4.2.1 The accuracy of the AC source is equal to the sum of the transfer standard accuracy and the accuracy of the DC source. The accuracy of the setup for each range and frequency used is provided in Table 3.24.

3.7.3 Procedure.

3.7.3.1 Allow two hours for warmup. **Connect the instrument and the test equipment as shown in the figure supplied with each accuracy check. Select the controls and inputs as called out in the tables and monitor the instrument readout** for the indicated values. The specification tests are performed using the front panel input connectors. (Front input is selected by pressing the SHIFT FR keys (ref 24 and 9, Figure 3.2 and Table 3.2) so that the RI annunciator is off (ref 29, Figure 3.1 and Table 3.1).

Table 3.25 - DC Range Check (Low Ranges)

DVM		INPUT SIGNAL				
FUNCTION	RANGE	DC VOLTAGE STANDARD	DIVIDER SETTING	NOMINAL READING (5-1/2 Digit Mode)	TOLERANCE (90 Day Spec)	NOTE
DC	100 mV	10.00000	.01000	100.000	099.992 – 100.008	23°C ± 5°C (After Auto Cal)
	1V	10.00000	.10000	1.00000	0.99997 – 1.00003	

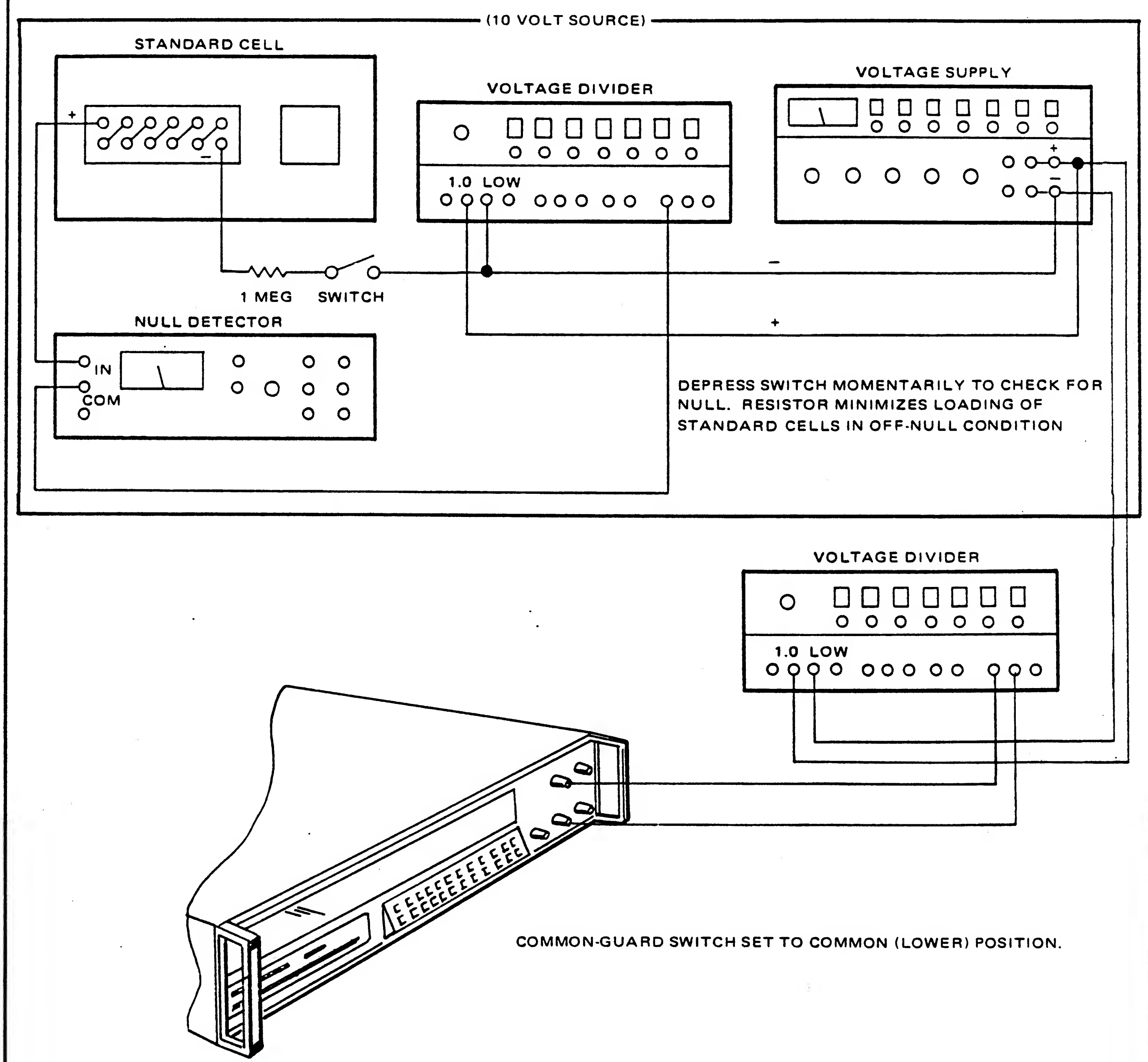
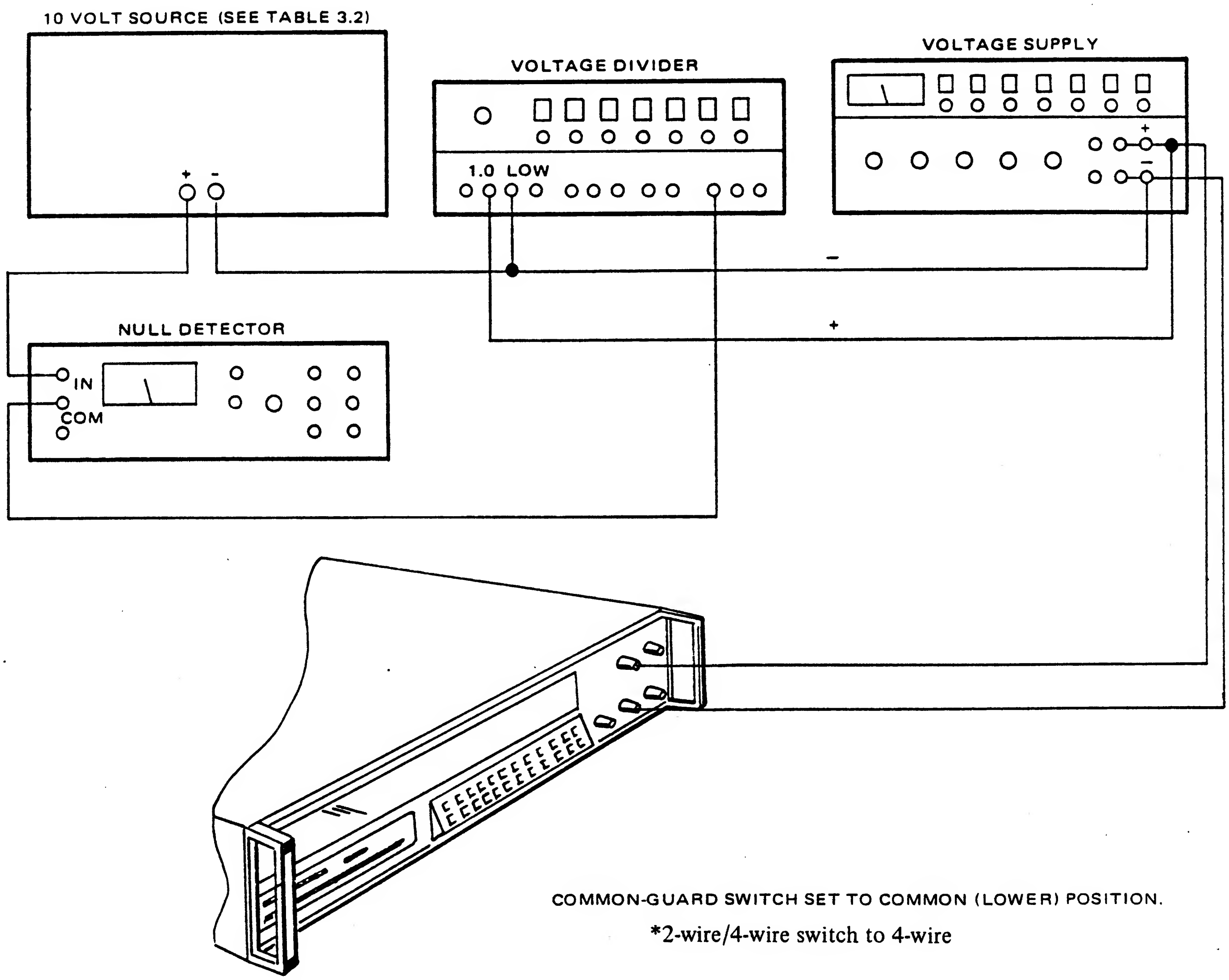


Table 3.26 - **DC Range Check (High Ranges)**

DVM		INPUT SIGNAL				
FUNCTION	RANGE	DC VOLTAGE STANDARD		NOMINAL READING (5 1/2 Digit Mode)	TOLERANCE (90 Day Spec)	NOTE
DC	10	10.0000V		10.0000	9.9998 – 10.0002	23°C ± 5°C (After Auto Cal) *
	100	100.000V		100.000	99.997 – 100.003	
	1000	1000.00V		1000.00	999.97 – 1000.03	



COMMON-GUARD SWITCH SET TO COMMON (LOWER) POSITION.

*2-wire/4-wire switch to 4-wire

Table 3.27 - 4-Wire Ratio Check (Option 34)

DVM		INPUT SIGNAL				
FUNCTION	RANGE	FRONT	REAR	NOMINAL READING	TOLERANCE (90 Day Spec)	NOTE
DC RATIO	10V	+1.00000	+1.00000	+1.00000	9.9960–1 – 1.00040	23°C ± 5°C (After Auto Cal)
		+10.0000	+10.0000	+1.00000	9.9960–1 – 1.00040	
		--10.0000	+10.0000	--1.00000	9.9960–1 – 1.00040	

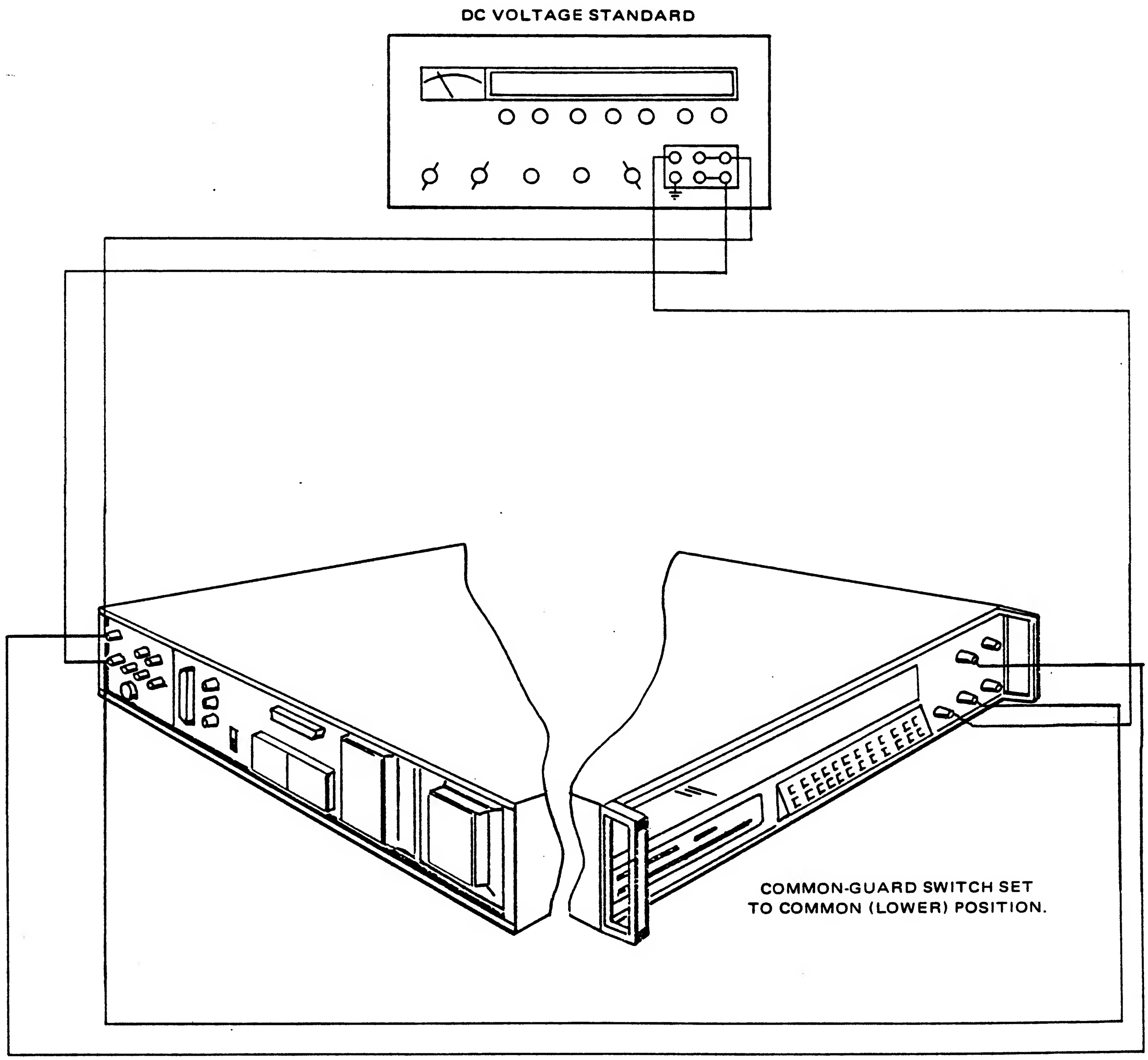
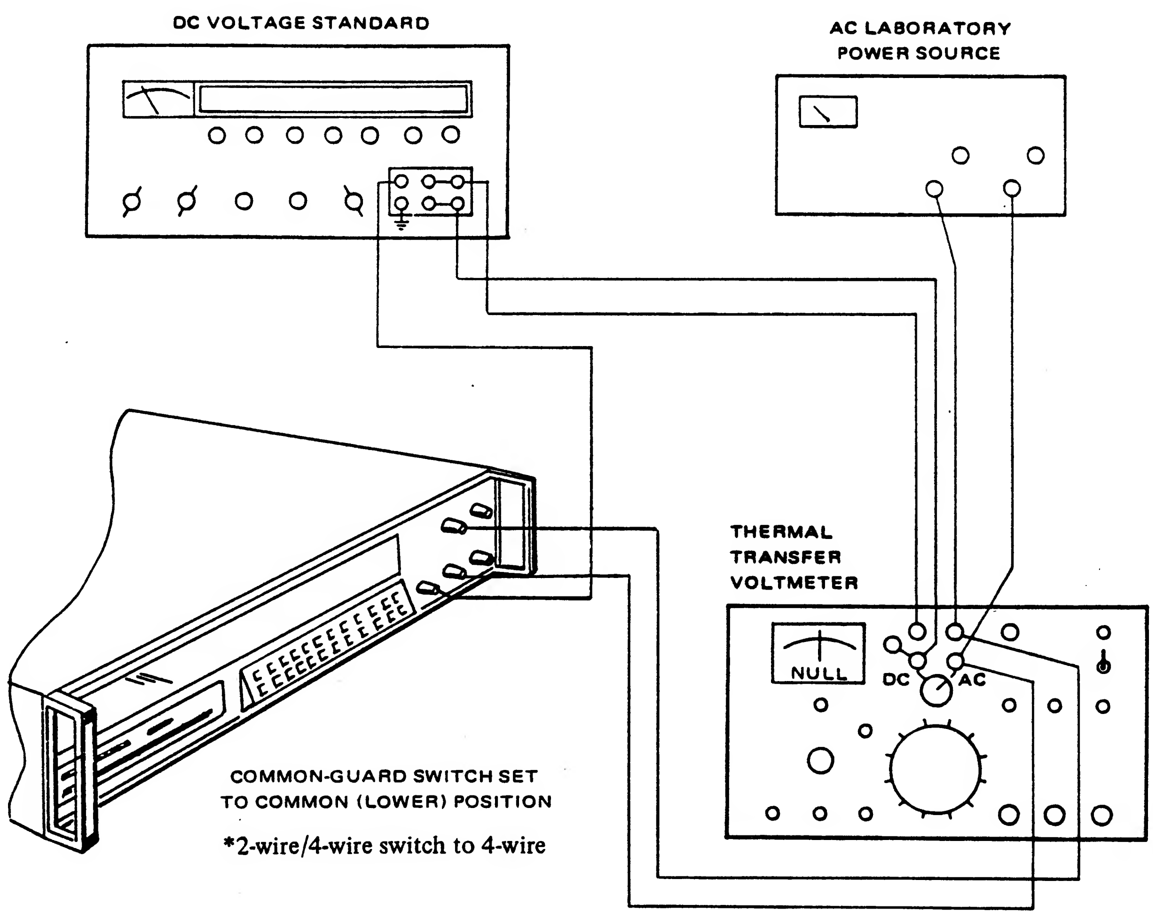


Table 3.28 - RMS AC Converter Range Check (Option 10)

DVM		INPUT SIGNAL				
FUNCTION	RANGE	DC VOLTAGE STANDARD	AC	NOMINAL READING (5-1/2 Digit Mode)	TOLERANCE	NOTE (90 Day Spec)
AC	1	1.000000	1V @ 400 Hz	1.00000	.99870 – 1.00130	23°C ± 5°C (After Auto Cal) *
		1.000000	1V @ 50 kHz	1.00000	.99800 – 1.00200	
	10	10.00000	10V @ 400 Hz	10.0000	9.9870 – 10.0130	
		10.00000	10V @ 50 kHz	10.0000	9.9800 – 10.0200	
	100	100.0000	100V @ 400 Hz	100.000	99.870 – 100.130	
		100.0000	100V @ 50 kHz	100.000	99.800 – 100.200	
	1000	1000.000	1000V @ 400 Hz	1000.00	997.40 – 1002.60	
		500.000	500V @ 40 kHz	500.00	498.50 – 501.50	



*2-wire/4-wire switch to 4-wire

Table 3.29 - AC/AC Ratio Check (Option 11)

DVM		INPUT SIGNAL				
FUNCTION	RANGE		AC	NOMINAL READING (5-1/2 Digit Mode)	TOLERANCE	NOTE (90 Day Spec)
AC HARDWARE RATIO	1		1V @ 400 Hz	1.00000	.99740 – 1.00260	23°C ± 5°C (After Auto Cal)
	10		10V @ 400 Hz	1.00000	.99740 – 1.00260	
	100		100V @ 400 Hz	1.00000	.99740 – 1.00260	
	1000		1000V @ 400 Hz	1.00000	.99540 – 1.00460	

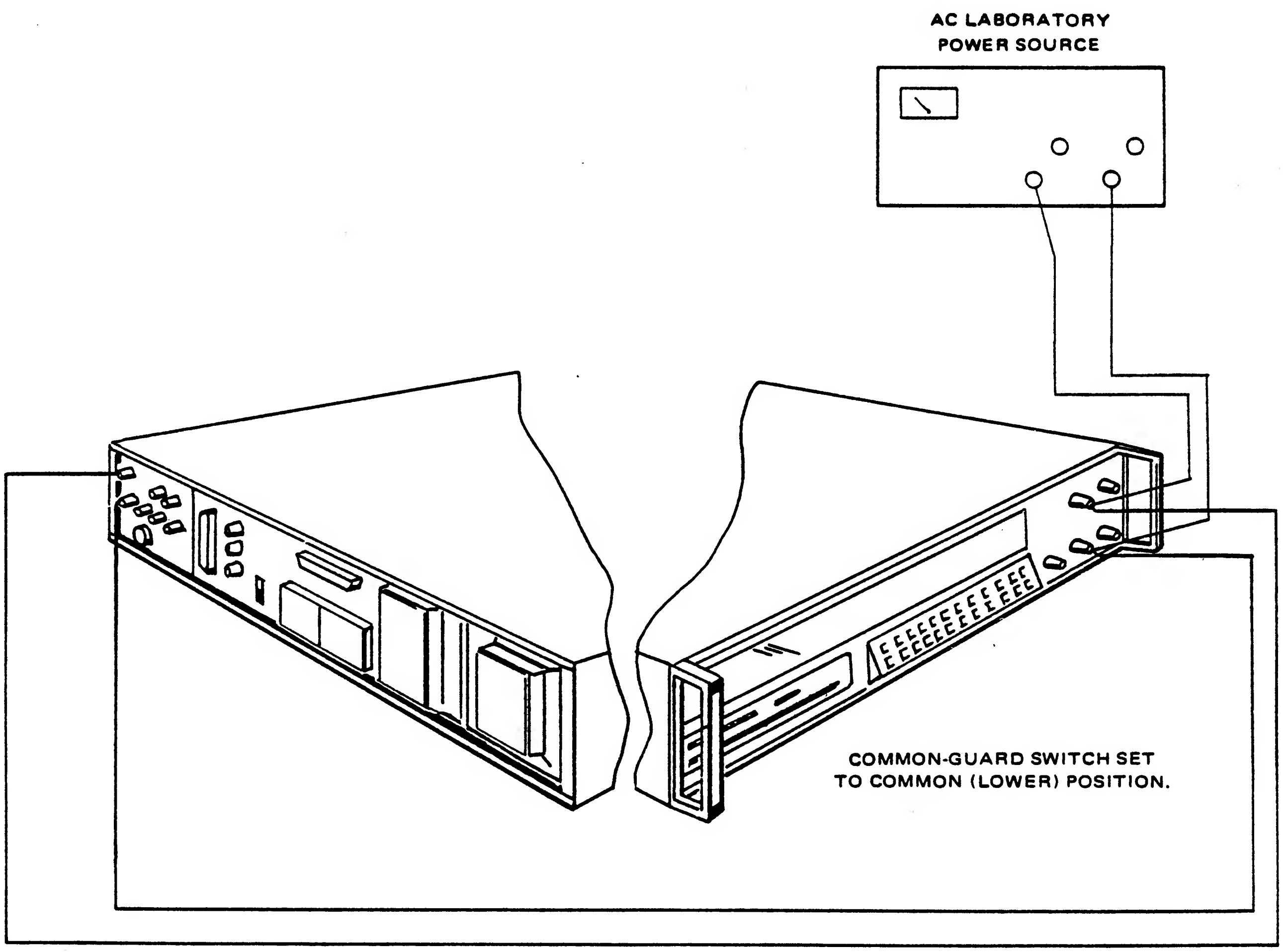
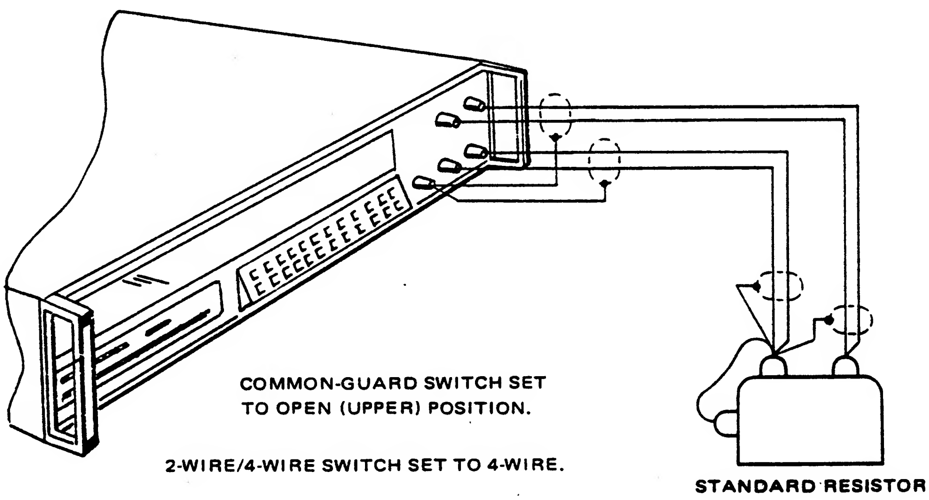


Table 3.30 - Ohms-Megohms Range Check (Options 24 and 41)

DVM		INPUT SIGNAL		NOMINAL READING (5-1/2 Digit Mode)	TOLERANCE* (90 Day Spec)
FUNCTION	**RANGE**	**NOMINAL STANDARD VALUE**	**STANDARD VALUE KNOWN TO WITHIN:**		
Ω - MΩ (Option 24)	10Ω	10Ω	±.001%	10.0000	±11 digits
	100Ω	100Ω	±.0005%	100.000	±5 digits
	1 kΩ	1 kΩ	±.0005%	1.00000	±5 digits
	10 kΩ	10 kΩ	±.0005%	10.0000	±5 digits
	100 kΩ	100 kΩ	±.0005%	100.000	±5 digits
	1 MΩ	1 MΩ	±.0005%	1.00000	±5 digits
	10 MΩ	10 MΩ	±.002%	10.0000	±33 digits
	100 MΩ*	100 MΩ	±.01%	100.000	±51 digits
Ω (Option 24 and 41)	1Ω	1Ω	.002%	1.00000	±40 digits (see procedure section 3.3.6)

*After Autocal



*Use cabling and Ohms Guard connections shown in Figures 3.5b or 3.5c for 100 MΩ measurement.

Table 3.31 - Common Mode Rejection (In DC Volts Function)

DVM		INPUT SIGNAL		NOMINAL READING (5-1/2 Digit Mode) See Note 1	TOLERANCE	NOTE
FUNCTION	RANGE	S1				
DCV FILT. OUT	100 mV	Off			±1 digit from nominal	1) With switch S-1 in the off position, record the reading displayed on the DMM's readout in the "nominal reading" boxes of the table.
		DC			± 50 digits from nominal	
		AC			±25 digits from nominal	
DCV FILT. IN	100 mV	DC			±50 digits from nominal	
		AC			± 2.5 digits from nominal	

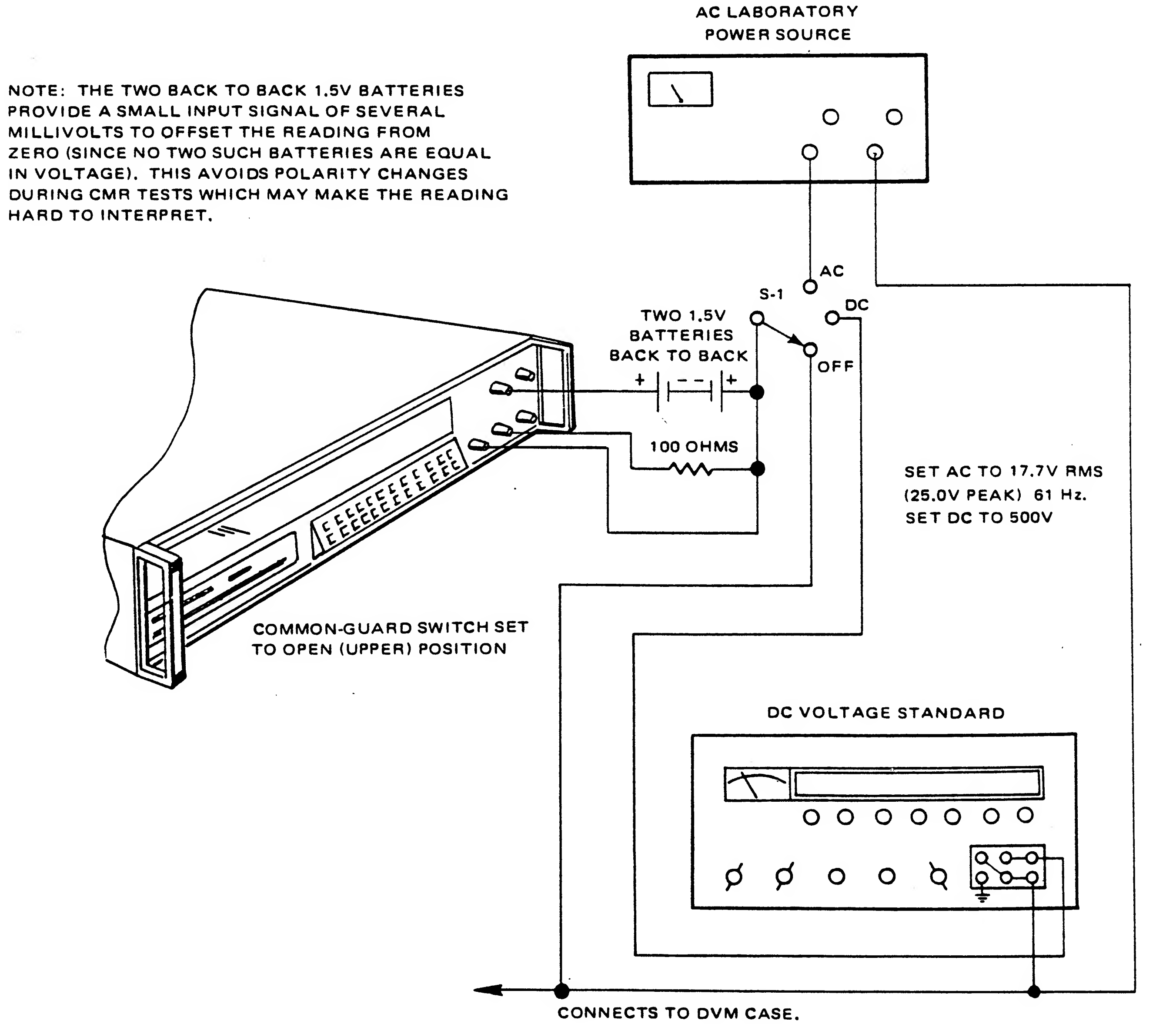


Table 3.32 - **Normal Mode Noise Rejection (In DC Volts Function)**

DVM		INPUT SIGNAL		NOMINAL READING (5-1/2 Digit Mode)	TOLERANCE	NOTE
FUNCTION	RANGE	DC	AC			
DC FILT. OUT	10	0.5V	10V*, 60 Hz†	00.5000	±400 digits	
FILT. IN	1V	0.5V	2V*, 60 Hz†	0.50000	± 2 digits	

*peak
†50 Hz (50 Hz Option)

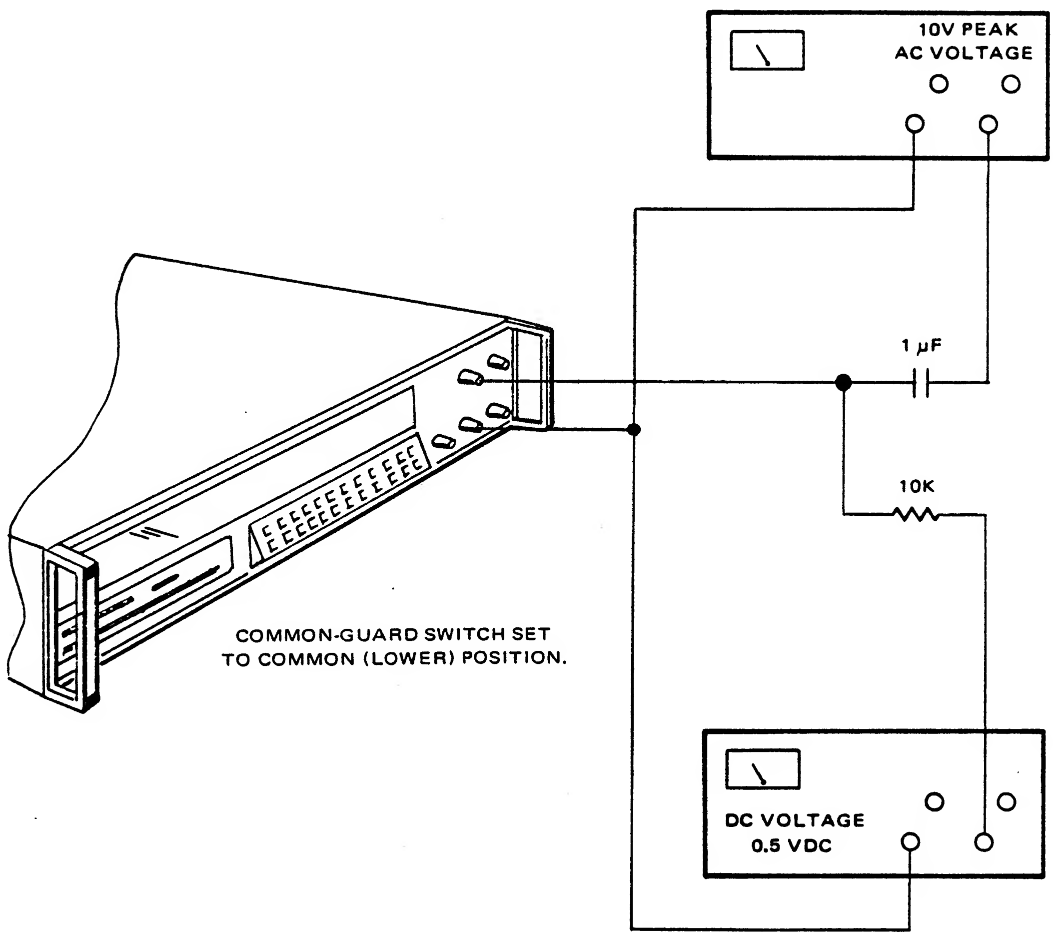
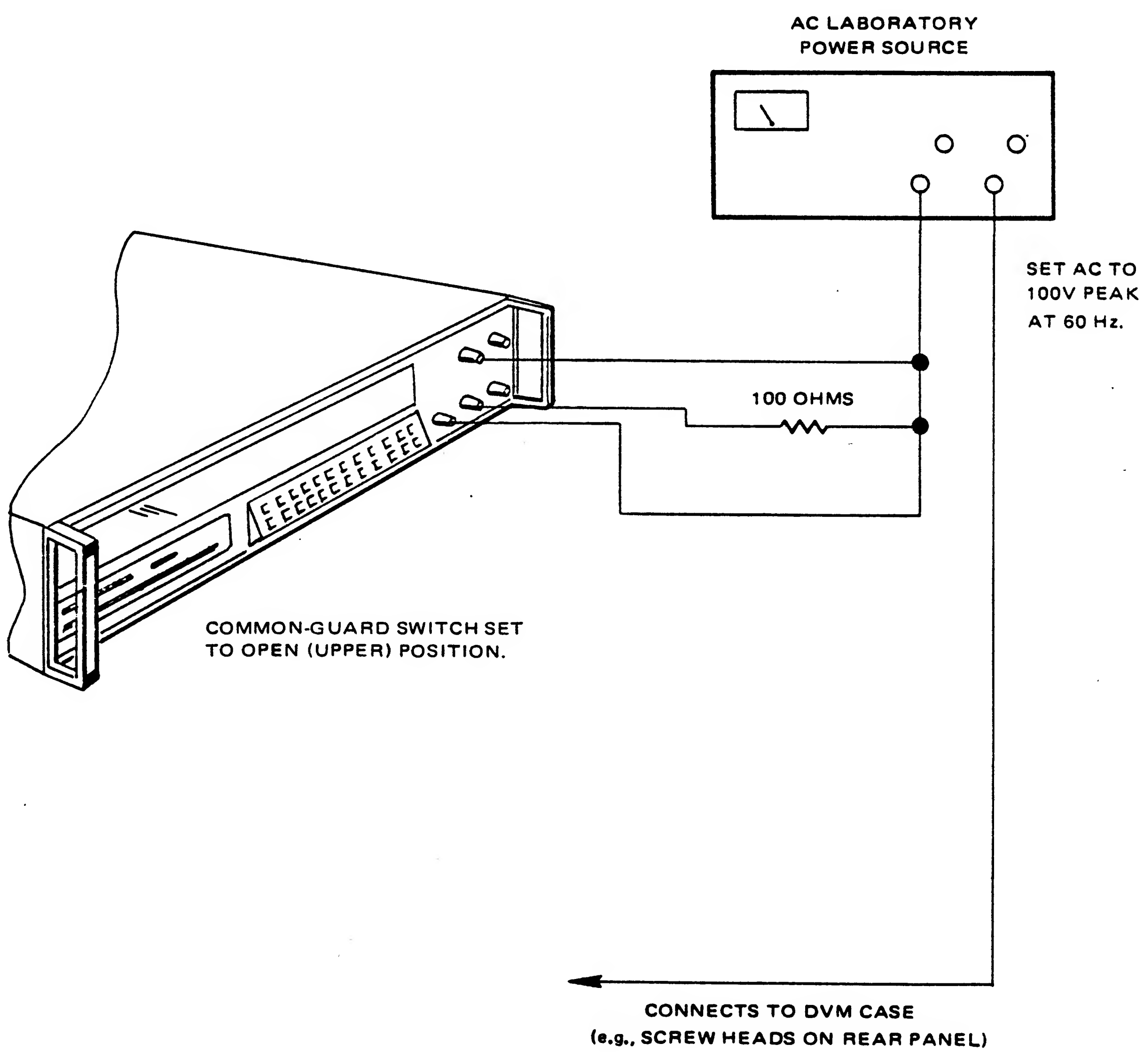


Table 3.33 - **Common Mode Rejection (In AC Volts Function)**

DVM		COMMON MODE INPUT SIGNAL		NOMINAL READING (see note)	TOLERANCE	NOTE
FUNCTION	RANGE	VOLTAGE	FREQ.			
AC	1	100V Peak	60 Hz		±10 digits	Enter reading with shorted input in nominal column before beginning
	10	100V Peak	60 Hz		±1 digit	
	100	100V Peak	60 Hz		±1 digit	
	1000	100V Peak	60 Hz		±1 digit	



3.8 LABORATORY CALIBRATION.

3.8.1 General procedures are presented in this subsection for recalibration of the Series 6000 Exchangeable Cal-Module. The Exchangeable Cal-Module allows a Series 6000 Amplitude Measurement System to be calibrated by exchanging the Calibration Module with a calibrated module, or calibrating the Module in place. If the Module is exchanged, the Module needing calibration can be plugged into another 6000 or a Calibration Test Assembly for calibration. See Table 3.22 for Test Equipment.

3.8.2 Calibration Setup.

3.8.2.1 Remove factory seal protecting Cal Switch, No. 10 on rear panel. Replace seal upon completion of calibration.

3.8.2.2 Apply power to instrument and allow at least 2 hours warmup at an ambient temperature of 23 $\pm$ 1°C. unless otherwise noted.

3.8.2.3 DIGICAL™ DIGITAL CALIBRATION.

3.8.2.3.1 Most of the Model 6000 functions and ranges may be calibrated from the front panel, without removing the covers. Correction factors are stored in non-volatile memory and remain valid even when power is removed from the DMM.

3.8.2.3.2 *Non-Volatile Memory Access.* Access to the Lab-Cal scale factors is provided so that they may be logged and compared with previous scale factors. Entry to non-volatile memory is made as follows:

Step	Key	Display
1	SHIFT ☐	SFT
2	MEM ☐	Contents of memory location 1.

3.8.2.3.3 The contents of succeeding memory locations may be displayed by toggling the UP ☐ UP key. Each press of the key will increment the memory location counter by one. Memory contents are listed in Table 3.34.

3.8.2.4 CALIBRATION TEST ASSEMBLY.

3.8.2.4.1 The Calibration Module may be inserted into a Series 6000 Calibration Test Assembly for calibration and/or troubleshooting. The Calibration Test Assembly electronics are fully compatible with the Model 6000 DMM, but the keyboard and annunciators have been modified to facilitate the calibration process (reference Figure 3.31).

Table 3.34 - Non-Vol Memory Contents

Memory Location	Scale Factor
1	+10 volt reference
2	Preamplifier gain
3	100 mV range gain
4	1 volt range gain
5	−10 volt reference
6	Attenuator −100 volt range
7	Attenuator −1000 volt range
8	1Ω range
9	10Ω range
10	100Ω range
11	1KΩ range
12	10KΩ reference resistor
13	100KΩ range
14	1MΩ range
15	10MΩ range
16	100MΩ range
17	
18	
19	Unused, may display
20	"Error 14" on some models.
21	
22	
23	
24	Auto-Cal inhibit bit – Auto-Cal is inhibited if the MSD is a zero and enabled if the MSD is a one.

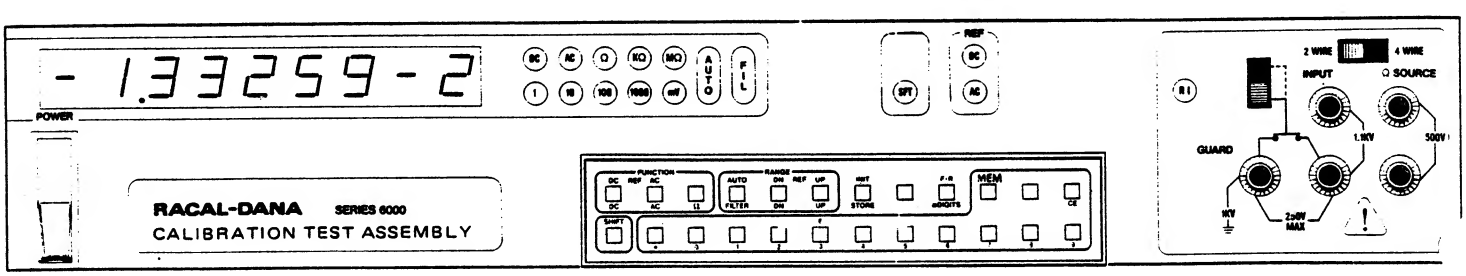


Figure 3.31 - Calibration Test Assembly Front Panel

3.8.3 Inhibiting Automatic Auto-Cal.

3.8.3.1 Automatic Auto-Cal may be temporarily inhibited by either a keyboard command (reference Table 3.2) or upon an instruction received at the systems interface. A more permanent inhibit command (unaffected by power switch cycling) may be entered into non-volatile memory as follows:

a. Perform Step 0 in Table 3.35
b. Press 0 (zero) Key
c. Press STORE Key

3.8.3.2 The Auto-Cal inhibit may be removed as follows:

a. Perform Step 0 in Table 3.35
b. Press 1 Key
c. Press STORE Key

3.8.4 Basic Cal-Module Calibration.

3.8.4.1 The Calibration Module for a basic DC measuring instrument (no options) is calibrated using steps 0-10 in Table 3.35.

3.8.5 Cal-Module Calibration With Options Installed.

3.8.5.1 OHMS (OPTION 24).

3.8.5.1.1 Perform DC and Ohms Calibration (steps 0-21 in Table 3.35).

> **NOTE**
>
> If the 100 mVDC, 1 VDC, 10 VDC and 10 mVDC (if installed) ranges perform within specification, DC calibration is not a prerequisite for Ohms Calibration and can be skipped.

3.8.5.2 TRUE RMS AC VOLTS (OPTION 10).

3.8.5.2.1 Perform DC Calibration (steps 0-10) and AC Calibration (steps 22-27) in Table 3.35.

> **NOTE**
>
> If the 1 VDC range performs within specifications. DC Calibration is not a prerequisite for AC Calibration and can be skipped.

3.8.5.3 AVERAGING AC VOLTS (OPTION 14).

3.8.5.3.1 Perform DC Calibration (steps 0-10) and AC Calibration (steps 22-26 and 28) in Table 3.35.

> **NOTE**
>
> If the 1 VDC range performs within specifications, DC Calibration is not a prerequisite for AC Calibration and can be skipped.

3.8.5.4 DC MILLIVOLTS (OPTION 41).

3.8.5.4.1 Perform DC Calibration (steps 0-10 in Table 3.35).

Table 3.35 - Laboratory Calibration Procedure

Step	Instruction	To Skip a Step	Display	Meaning
0	Move CAL SW ON (up), on Rear Panel # 10. Note: Remove Factory Seal.		Lb CAL 0 Err 33	Go to 1a to Calibrate DC Function. Go to 1b to Skip. Non-Vol. memory will not write
		DC CALIBRATION		
1a	Press FILTER Key to proceed with DC Calibration		Lb CAL 1	Go to 2
1b	Press DN Key to Skip all DC Calibration		OH CAL 0	DC CAL has been Skipped. Go to 11.
2	Apply −10V IN and press FILTER Key	Not Allowed WAIT FOR –	Lb CAL 1 Lb CAL 2	Internal Operation Go to 3
3	Apply +10V IN and press FILTER Key	Not Allowed WAIT FOR –	Lb CAL 2 Lb CAL 3	Internal Operation Go to 4
4	Apply 0.0V IN and press FILTER Key	Not Allowed	dc CAL 5 dc CAL 6 dc CAL 7 dc CAL 8 −1.00XXX (nominal)	Internal Operation Internal Operation Internal Operation Internal Operation if 10 mV Option Installed Normalized Value of −10V Reference Go to 4a
4a	Press FILTER Key	Not Allowed	1.00XXX (nominal)	Normalized Value of +10V Reference Go to 4b
4b	Press FILTER Key	Not Allowed	Lb CAL 4 10 mV Range Lb CAL 4 100 mV Range	Go to 5 if 10 mV Option installed. Go to 6
5	Apply +0.01V IN and press FILTER Key	Press DN Key and go to 6	7.2XXXX−1 (nominal)	Scale Factor - 10 mV Range Go to 5a
5a	Press FILTER Key		Lb CAL 4 100 mV Range	Go to 6

Table 3.35 - Laboratory Calibration Procedure continued

Step	Instruction	To Skip a Step	Display	Meaning
6	Apply +0.10V IN and press FILTER Key	Press DN Key and go to 7	1.XXXXX (nominal)	Scale Factor - 100 mV Range Go to 6a
6a	Press FILTER Key		Lb CAL 4 1V Range	Go to 7
7	Apply +1.0V IN and press FILTER Key	Press DN Key and go to 8	1.XXXXX (nominal)	Scale Factor - 1V Range Go to 7a
7a	Press FILTER Key	----	Lb CAL 4 100V Range	Go to 8
8	Apply +100V IN and press FILTER Key	Press DN Key and go to 9	1.XXXXX (nominal)	Scale Factor - 100V Range Go to 8a
8a	Press FILTER Key	----	Lb CAL 4 1000V Range	Go to 9
9	Apply +1000V IN and press FILTER Key	Press DN Key and go to 10	1.XXXXX (nominal)	Scale Factor - 1000V Range Go to 9a
9a	Press FILTER Key	----	Lb CAL 5 1000V Range	Go to 10
10	Remove +1000V IN	Press DN Key and go to 11 (OH CAL 0) or 22 (AC CAL 0)	Lb CAL 5	Remove 1000V IN before proceeding. Go to 10a
10a	Press FILTER Key		OH CAL 0 AC CAL 0 Lb CAL E	Go to 11 Go to 22 Lab CAL is terminated Go to 10b
10b	Move CAL SW Off (Down) If not	Doing Ω or AC	6000	
		OHMS CALIBRATION		
11			OH CAL 0	Go to 11a to Calibrate Ohms Function. Go to 11b to Skip.
11a	Press FILTER Key to proceed with Ohms Calibration		Lb CAL 6	Go to 12
11b	Press DN Key to Skip all Ohms Calibration		AC CAL 0 Lb CAL E	Ohms CAL has been Skipped. Go to 22. Lab CAL is terminated Go to 21

Table 3.35 - Laboratory Calibration Procedure continued

Step	Instruction	To Skip a Step	Display	Meaning
12	Apply zero ohms in 4-wire connection and press FILTER Key (See Figure 3.29 for connections if 1Ω option installed).	Not Allowed	OH CAL 1 OH CAL 2 OH CAL 3 OH CAL 4 OH CAL 5 OH CAL 6 Lb CAL 7 10 KΩ Range	Internal Operation Internal Operation Internal Operation Internal Operation Internal Operation Internal Operation (if 1Ω option installed) Go to 12a
12a	Apply 10KΩ Std. in 4-wire connection. Enter correction factor for resistance std. (See Note 1) and press STORE Key	Not Allowed	1.0XXXX 1 1 (nominal)	Normalized Value of Internal 10KΩ Ref. Resistor Go to 12b
12b	Press FILTER Key		Lb CAL 7 1Ω Range Lb CAL 7 10Ω Range	Go to 13 if 1Ω option installed. Go to 14
13	Apply 1Ω Std. in 4-wire connection. Enter correction factor for resistance std. (See Note 1) and press STORE Key	Press DN Key and go to 14	1.XXXXX 1 (nominal)	Scale Factor - 1Ω Range Go to 13a
13a	Press FILTER Key		Lb CAL 7 10Ω Range	Go to 14
14	Apply 10Ω Std. in 4-wire connection. Enter correction factor for resistance std. (See Note 1) and press STORE Key	Press DN Key and go to 15	−1.XXXXX 1 (nominal)	Scale Factor - 10Ω Range Go to 14a
14a	Press FILTER Key		Lb CAL 7 100Ω Range	Go to 15
15	Apply 100Ω Std. in 4-wire connection. Enter correction factor for resistance std. (See Note 1) and press STORE Key	Press DN Key and go to 16	−1.XXXXX 1 (nominal)	Scale Factor - 100Ω Range Go to 15a
15a	Press FILTER Key		Lb CAL 7 1 KΩ Range	Go to 16
16	Apply 1KΩ Std. in 4-wire connection. Enter correction factor for resistance std. (See Note 1) and press STORE Key	Press DN Key and go to 17	−1.XXXXX 1 (nominal)	Scale Factor - 1 KΩ Range Go to 16a
16a	Press FILTER Key		Lb CAL 7 100 KΩ Range	Go to 17

Table 3.35 - Laboratory Calibration Procedure continued

Step	Instruction	To Skip a Step	Display	Meaning
17	Apply 100KΩ Std. in 4-wire connection. Enter correction factor for resistance std. (See Note 1) and press STORE Key	Press DN Key and go to 18	1.XXXXX 1 (nominal)	Scale Factor - 100 KΩ Range Go to 17a
17a	Press FILTER Key		Lb CAL 7 1 MΩ Range	Go to 18
18	Apply 1MΩ Std. in 4-wire connection. Enter correction factor for resistance std. (See Note 1) and press STORE Key	Press DN Key and go to 19	1.XXXXX 1 (nominal)	Scale Factor - 1 MΩ Range Go to 18a
18a	Press FILTER Key		Lb CAL 7 10 MΩ Range	Go to 19
19	Apply 10MΩ Std. in 4-wire connection. Enter correction factor for resistance std. (See Note 1) and press STORE Key	Press DN Key and go to 20	1.XXXXX 1 (nominal)	Scale Factor - 10 MΩ Range Go to 19a
19a	Press FILTER Key		Lb CAL 7 100 MΩ Range	Go to 20
20	Apply 100MΩ Std. in 4-wire connection. Enter correction factor for resistance std. (See Note 1) and press STORE Key	Press DN Key and go to 20a	1.XXXXX 1 (nominal)	Scale Factor - 100 MΩ Range Go to 20a
20a	Press FILTER Key		Lb CAL E AC CAL 0	Lab CAL is terminated Go to 21 Go to 22
21	Move CAL SW OFF (Down)		6000	

Note 1 - $\text{Correction Factor} = \dfrac{\text{Actual Value of Std}}{\text{Theoretical Value of Std}}$

e.g. $\dfrac{99.9983\ K\Omega}{100\ K\Omega} = .99998$

or

$\dfrac{10.0003\ K\Omega}{10\ K\Omega} = 1.00003$

Table 3.35 - Laboratory Calibration Procedure continued

Step	Instruction	Display	Meaning
	AC CALIBRATION		
22		AC CAL 0	Go to 23 to skip all AC calibration Go to 24 to prepare software for AC converter calibration.
23	Press DN Key	Lb CAL E	AC calibration steps have been skipped. Go to 26.
24	Press FILTER Key	Lb CAL 8	Go to 25.
25	Press FILTER Key	Lb CAL E	Software is prepared for AC converter calibration. Go to 26.
26	Move CAL SW OFF (Down)	6000	Calibration is complete unless AC board calibration has not been performed. To calibrate RMS Converter go to 27. To calibrate Averaging Converter go to 28.
27	RMS Converter Calibration		
27a	Install calibration cover (454278) on Calibration Module and allow at least 30 minutes for warmup.		
27b	Select DC Coupled AC (depress AC and DC keys simultaneously) and 1 VAC Range. Connect jumper across input terminals.		
27c	Connect a 10 KΩ resistor in series with + microvoltmeter lead for all the following measurements.		
27d	Turn R53 fully CCW. Connect microvoltmeter to TP3 (+) and TP1 (–). Adjust R71 for microvoltmeter reading of zero $\pm 30\ \mu V$. Remove microvoltmeter + lead from TP3. NOTE: Microvoltmeter negative lead remains connected to TP1 for all measurements.		
27e	Connect + microvoltmeter lead to TP2. Adjust R54 for microvoltmeter reading of $+20\ \mu V \pm 10\ \mu V$.		
27f	Connect + microvoltmeter lead to TP5. Adjust R63 for microvoltmeter reading of zero $\pm 30\ \mu V$.		

Table 3.35 - Laboratory Calibration Procedure continued

27g	Connect + microvoltmeter lead to TP4. Adjust R62 for zero ± 30 mV.
27h	Connect + microvoltmeter lead to TP2. Adjust R53 clockwise for a microvoltmeter reading of zero ± 5 μV.
27i	Remove microvoltmeter leads.
27j	Apply −1.000---VDC to input and note display reading.
27k	Apply +1.000- - -VDC and adjust R55 to obtain the same reading as in 27j. Repeat steps j and k until the two readings are within 10 digits (.01%) of each other.
27l	Apply −0.100- - -VDC to DVM input directly from DC Calibrator (do not use an attenuator) and note display reading.
27m	Apply +0.100- - -VDC and adjust R62 until reading agrees within ± 5 digits of step l. Repeat steps j through m as necessary.
27n	Remove DC Calibrator from input.
27o	If the remaining adjustments are performed with the instrument top cover removed. optimum accuracy will not be achieved. Best accuracy will result from installing top cover and allowing at least 30 minutes for internal temperature to stabilize. Perform adjustments by lifting the edge of the cover just long enough to perform each adjustment.
27p	Select AC mode, 1.0V Range. Apply .1 VAC, 500 Hz and adjust R73 for display reading of 0.10000.
27q	Apply 1.0 VAC, 500 Hz and adjust R45 for display reading of 1.00000. Repeat steps p and q until both readings are correct.
27r	Calibrate the 1000V and 1V ranges according to the following table. Range / Input / Frequency / Adjustment 1000V / 500 VAC / 500 Hz / R67 (500V LF) 1000V / 500 VAC / 30 kHz / C27 (500V HF) 1V / 1 VAC / 40 kHz / C28 (1V HF) **WARNING** Lethal voltages are present. Use an insulated adjustment tool.
27s	Perform step t only if major repairs have been performed on the RMS converter. Otherwise proceed to step v.
27t	Apply a calibrated 1.0V rms pulse train with a crest factor of 7 and a period of 1 millisecond (1 KHz repetition rate). Adjust R52 for a readout of 1.00000 ± 10 digits.

Table 3.35 - Laboratory Calibration Procedure continued

27u	Repeat steps p, q and t until all readings are correct.
27v	Calibrate 1, 10, and 100V ranges according to the following table. Range / Input / Frequency / Adjustment 10V / 10 VAC / 500 Hz / R65 (10V LF) 100V / 100 VAC / 500 Hz / R64 (100V LF) 1V / 1 VAC / 40 kHz / C28, if necessary (1V LF) 10V / 10 VAC / 40 kHz / C24 (10V HF) 100V / 100 VAC / 40 kHz / C23 (100V HF)
27w	Repeat step p.
27x	Perform 5 1/2 digit Auto-Cal (#Digits, 5).
28	Averaging Converter Calibration.
28a	Remove Scaling Amplifier from J304 and install a Scaling Amplifier Bypass board (411628) in its place. Install AC Converter PCB on an extender board.
28b	Select AC function (any range) and leave input terminals open.
28c	Connect the – microvoltmeter lead to TP2. Connect the + microvoltmeter lead through a 10KΩ series resistor to TP5. Adjust R40 for a microvoltmeter reading of zero ± 10 μV.
28d	Connect the + microvoltmeter lead alternately between TP1 and TP3. Adjust R46 so that the voltage readings are balanced within 10 μV of each other and the voltage at each point is zero ± 20 μV.
28e	Remove microvoltmeter leads.
28f	Apply 1.0 VAC at 1 KHz to the input terminals and record the readout. Change the input to 1.0 VAC at 100 KHz. Adjust C13 until the readout is within ± 10 digits of the recorded value (5 1/2 digit mode).
28g	Remove voltage from input terminals. Remove AC Converter PCB from extender board. Install AC Converter in J303.

Table 3.35 - Laboratory Calibration Procedure continued

28h	Remove Scaling Amplifier Bypass board and install Scaling Amplifier in J304. Install the calibration cover (454251) on the Calibration Module and allow one hour for warmup.
28i	Select AC function, 1V range. Perform 5 1/2 digit Auto-Cal (#DIGITS, 5) and verify that AC CAL 1 and AC CAL 2 do not appear.
28j	Connect the AC Calibrator to the input terminals and apply 10 mV at 1 KHz. Adjust R50 on the AC Converter PCB for a readout of .01000V.
28k	Apply 1.0V at 1 KHz and adjust R39 (1V LF) on the Scaling Amplifier for a readout of 1.00000V ± 2 digits.
28l	Repeat steps j and k as required.
28m	Set C42 to the center of its span and then calibrate the 1V, 10V, 100V and 1000V ranges according to the following table:

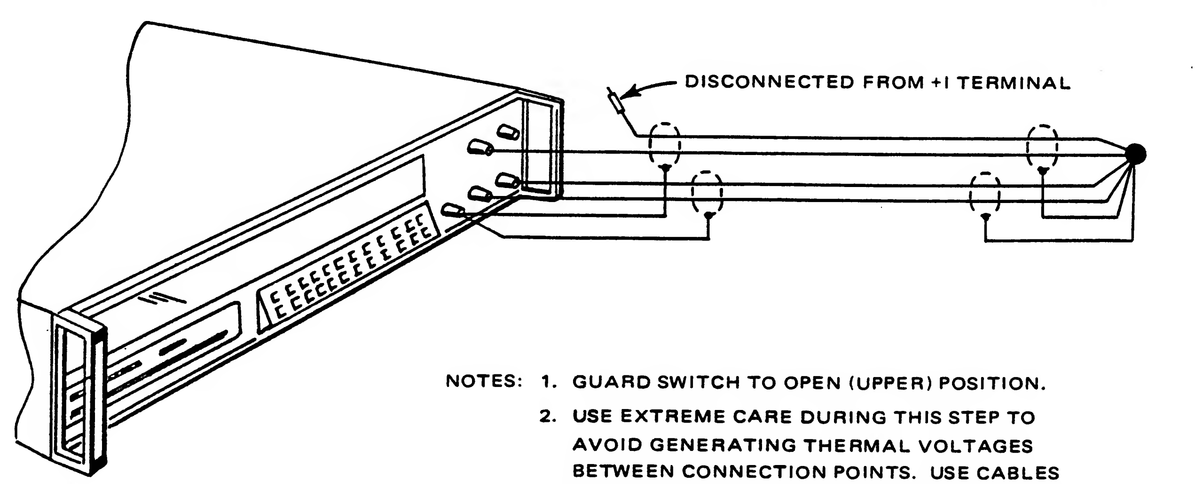
Range	Input	Frequency	Adjustment
10V	10 VAC	1 KHz	R31 (10V LF)
100V	100 VAC	1 KHz	R30 (100V LF)
1000V	1000 VAC	1 KHz	R29 (1KV LF)
1000V	500 VAC	40 KHz	C36 (500V HF)
1V	1 VAC	100 KHz	C40 (1V HF)
10V	10 VAC	100 KHz	C28 (10V HF)
100V	100 VAC	100 KHz	C27 (100V HF)

WARNING

Lethal voltages are present. Use an insulated adjustment tool.

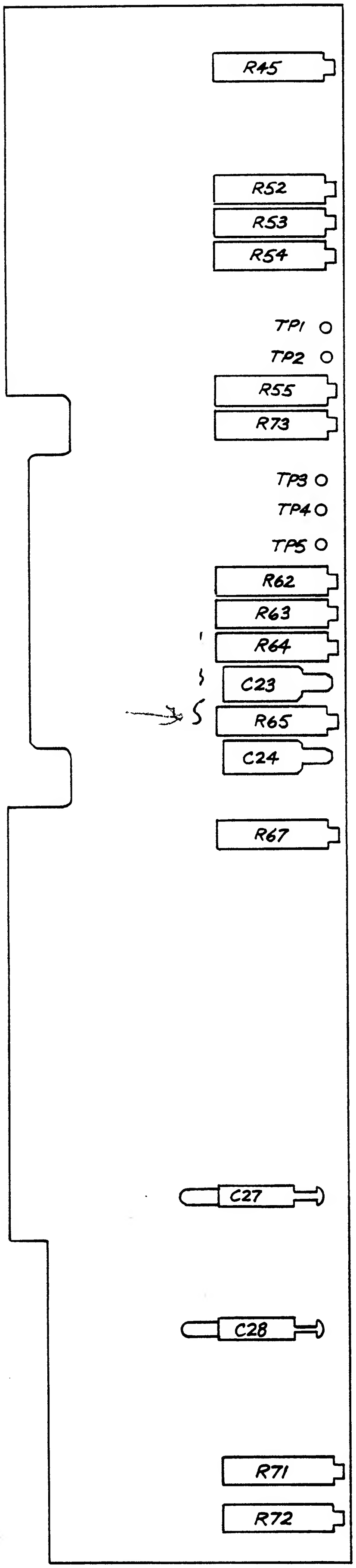
28n	Perform 5 1/2 digit Auto-Cal (#Digits, 5).
29	AC Frequency Linearity Check
29a	Perform an AC frequency linearity check by applying a full-scale AC voltage in each range and sweeping the frequency from 10KHz to the upper spec limit. If one or more points are found to be out of spec, correct by tweaking the high-frequency adjustment for the associated range.

Note: Replace seal over Cal Switch upon completion of calibration.

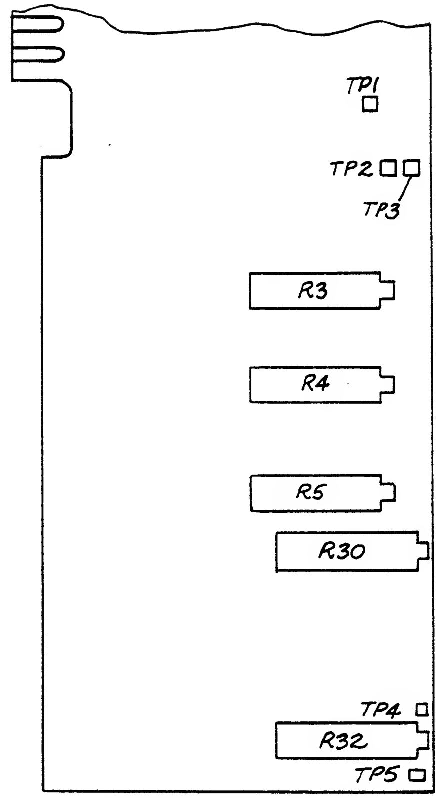


NOTES: 1. GUARD SWITCH TO OPEN (UPPER) POSITION.
2. USE EXTREME CARE DURING THIS STEP TO AVOID GENERATING THERMAL VOLTAGES BETWEEN CONNECTION POINTS. USE CABLES WITH KELVIN CLIPS OR OTHER LOW THERMAL TERMINATIONS AT ZERO RESISTANCE CONNECTION.

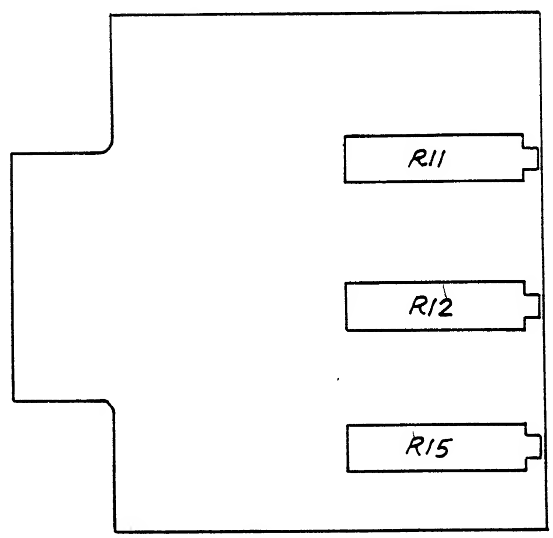
Figure 3.32 - Zero Ohms Connection For DMM's With 1 Ohm Range



RMS Converter PCB
401618

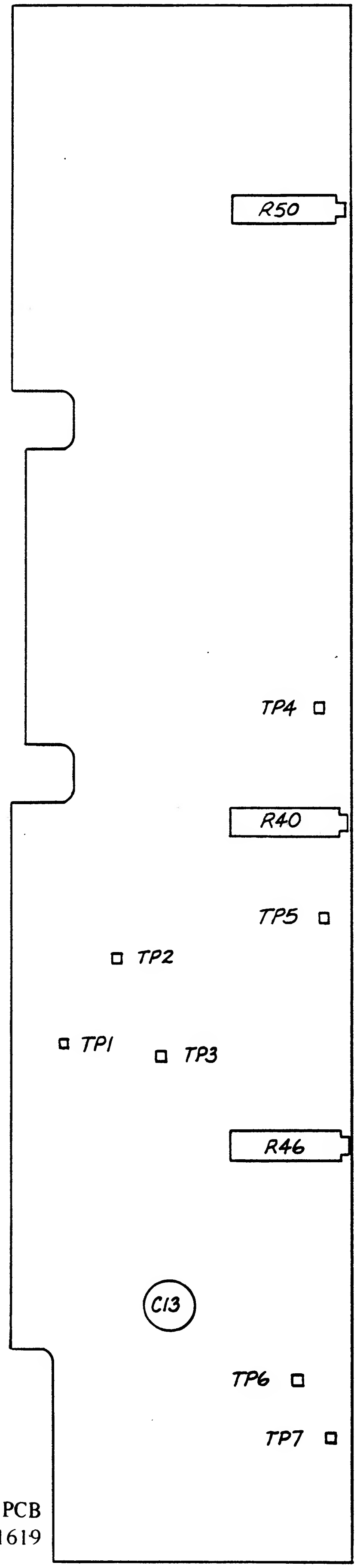


Attenuator Reference PCB
401608

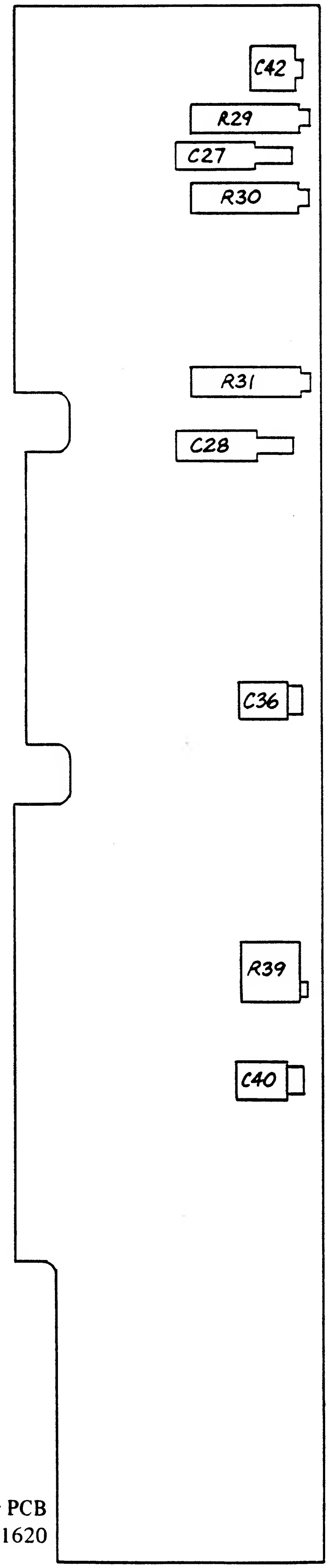


4-Wire Ratio PCB
401626

Figure 3.33 - Calibration Adjustment Locations



AC Converter PCB
401619



Scaling Amplifier PCB
401620

Figure 3.33 - Calibration Adjustment Locations continued

3.8.5.5 4-WIRE RATIO (OPTION 34).

a. The following equipment is required in addition to the items listed in Table 3.22.

   1. 5 1/2 Digit DVM with ± .001% F.S. accuracy on 10 VDC range, e.g., Racal-Dana 6000 or 5900.

   2. 410764 AC Ratio Bypass/4-Wire DC Ratio Bypass card (2 required).

b. Perform Internal Reference Adjustments given in paragraph 3.8.6.

> **CAUTION**
>
> Adjustment of internal reference voltages per paragraph 3.8.6 will invalidate any previous calibration of the instrument. These adjustments, if needed, must be performed prior to other calibrations.

c. Install a 4-Wire Ratio board in J305 and a Ratio Switching board in J306. Install the calibration cover on the Calibration Module and allow at least one hour warmup.

d. Select DC External Reference (SHIFT, HDW, DC). Verify that DC REF annunciator light is ON.

e. Connect a DC Voltage Calibrator to the EXT REF terminals. Connect a jumper from positive terminal of EXT REF input to –INPUT terminal on front panel.

f. Connect the 5 1/2 Digit test DVM (positive lead) to TP2 on the Attenuator/Reference board, and the negative lead to Gnd pin on Motherboard (near Non-Volatile Memory PCB bracket).

g. Apply +1.00000 VDC to EXT REF input from DC Voltage Calibrator. Adjust R12 on 4-Wire Ratio board for +1.00000V on test DVM set to 1.0V range.

h. Increase EXT REF input to 10.0000 VDC. Adjust R11 on 4-Wire Ratio board for +10.0000V on test DVM set to 10V range.

i. Repeat steps g and h as required.

j. Remove jumper from positive terminal of EXT REF input and connect to minus terminal of EXT REF input (other end remains connected to –INPUT).

k. Verify that DC Voltage Calibrator is set to 10.0000 VDC. Adjust R15 on 4-Wire Ratio Board for +10.0000V on test DVM.

l. Decrease EXT REF input to 1.00000 VDC and verify a +1.0000V reading on test DVM set to 10 VDC range.

m. Remove test DVM.

n. Perform DC Calibration using steps 0-10 in Table 3.34.

o. Set 6000 to 10 VDC range and select DC External Reference (SHIFT, HDW, DC). Apply +10.0000 VDC to front panel INPUT and EXT REF input from the same Calibrator. Select 5 1/2 digit Auto-Cal (#DIG., 5) and verify a display reading of 1.00000 ± 2 digits.

p. Reduce calibrator voltage to +1.0000 VDC and select 5 1/2 digit Auto-Cal (# DIG., 5). Verify a display reading of 1.00000 ± 20 digits.

3.8.5.6 AC RATIO (OPTION 11).

a. See 3.8.5.5.a for test equipment requirements.

b. Perform Internal Reference Adjustments given in paragraph 3.8.6.

> **CAUTION**
>
> Adjustment of internal reference voltages per paragraph 3.8.6 will invalidate any previous calibration of the instrument. These adjustments, if needed, must be performed prior to other calibrations.

c. Remove the bypass board and install the Ratio Switching board in J306. Install the calibration cover on the Calibration Module and allow at least one hour warmup.

d. Select DC Coupled AC External Reference range as follows:

   1. Press SHIFT Key

   2. Press HDW Key

   3. Press AC and DC Keys simultaneously

   4. Verify that AC REF and DC REF annunciator lights are ON.

e. Select 1V External Reference Range as follows:

   1. Press SHIFT Key

   2. Press DN Key and note which Range annunciator light is ON while holding DN key depressed. Repeat SHIFT, DN commands until 1V annunciator light is ON while holding DN key depressed.

f. Connect a jumper between EXT REF terminals.

g. Connect a 10KΩ resistor in series with + microvoltmeter lead for all the following measurements. All adjustments are on the REF RMS Converter Card.

h. Connect positive microvoltmeter to TP3 and negative lead to TP1. Adjust R71 for microvoltmeter reading of zero ±30 μV. Remove microvoltmeter + lead from TP3. Turn R53 fully CCW.

NOTE

Microvoltmeter negative lead remains connected to TP1 for all measurements.

i. Connect + microvoltmeter lead to TP2. Adjust R54 for microvoltmeter reading of +20μV ± 10μV.

j. Connect + microvoltmeter lead to TP5. Adjust R63 for microvoltmeter reading of zero ±30 μV.

k. Connect + microvoltmeter lead to TP4. Adjust R62 for zero ±30 mV.

l. Connect + microvoltmeter lead to TP2. Adjust R53 clockwise for a microvoltmeter reading of zero ±5 μV.

m. Remove microvoltmeter leads. Connect the 5 1/2 digit test DVM (positive lead) to TP2 on the Attenuator/Reference board, and the negative lead to Gnd pin on Motherboard. Set test DVM to 10 VDC range.

n. Apply −1.0000 VDC to EXT REF terminals and note test DVM reading (approximately +10 VDC).

o. Apply +1.0000 VDC and adjust R55 to obtain the same reading as in step N. Repeat steps N and O until the two readings are within 10 digits (.01%) of each other.

p. Apply −0.1000 VDC to EXT REF terminals directly from DC Calibrator (do not use an attenuator) and note test DVM reading (approximately +1 VDC on 10 VDC range).

q. Apply +0.1000 VDC to EXT REF terminals and adjust R62 until the reading agrees with ±5 digits of step P.

r. Remove the DC Calibrator from the EXT REF terminals and connect the AC Calibrator.

s. Select capacitive coupled AC EXT REF (SHIFT, HDW, AC) and the 1V external reference range (see step E).

t. Apply 100 mVAC, 500 Hz to EXT REF and adjust R73 for a reading of 1.0000 VDC on the test DVM.

NOTE

The test DVM remains on the 10 VDC range during all these steps.

u. Set AC calibrator to 1 VAC, 500 Hz and adjust R45 for a reading of 10.0000 VDC on the test DVM. Repeat steps t and u until all readings are optimized. optimized.

v. Calibrate the 1000V and 1V Reference Ranges according to the following table.

Ext. Ref. Range	Ext. Ref. Input	Ref. RMS Converter Adjustment	Test DVM Reading
1000V	500 VAC, 500 Hz	R67	5.0000 VDC
1000V	500 VAC, 30 KHz	C27	5.0000 VDC
1V	1 VAC, 40 KHz	C28	10.0000 VDC

w. Perform steps x and y only if major repairs were performed on the Reference RMS Converter.

x. Apply a 1.0V RMS pulse train with a 7:1 crest factor and adjust R52 for a reading of 10.0000 VDC ± 10 digits on the test DVM.

y. Repeat steps t and u on the 1V Reference Range until all readings are optimized.

z. Calibrate 1, 10 and 100V Reference Ranges according to the following table.

Ext. Ref. Range	Ext. Ref. Input	Ref. RMS Converter Adjustment	Test DVM Reading
10V	10 VAC, 500 Hz	R65	10.0000 VDC
100V	100 VAC, 500 Hz	R64	10.0000 VDC
1V	1 VAC, 40 KHz	C28	10.0000 VDC
10V	10 VAC, 40 KHz	C24	10.0000 VDC
100V	100 VAC, 40 KHz	C23	10.0000 VDC

3.8.5.7 SAMPLE AND HOLD FAST A/D (OPTION 03SH).

a. Press #DIGITS 3 on the 6000 keyboard to produce internal trigger pulses.

b. Command the 6000, as follows, to read analog voltages applied to the Sample and Hold Fast A/D output connector:

1. If the DMM is connected to a GPIB controller, send the GPIB command G1.

2. If the DMM is not connected to a GPIB controller, short pin 16 and pin 19 of the Sample and Hold Fast A/D connector.

c. Perform the calibration procedures shown below. The input voltages are applied between pin 24 (use as voltage input common) and pin 25 of the Sample and Hold Fast A/D connector.

Voltage In	6000 Readout	Instruction
−10.240 ± .005	−2000	Adjust R26 & R24 together to get −2000 on readout.
+10.230 ± .005	2000	Adjust R26 & R24 together to get 2000 on readout.
Repeat steps a and b until readout agrees with voltage in.		
−5.120 ± .005	−1000	Check ± 1/2 count error (± 5mV)
5.110 ± .005	1000	Check ± 1/2 count error (± 5mV)

3.8.6 Internal Reference Adjustments.

NOTE

These adjustments are necessary only for instruments containing 4-Wire Ratio Option 34 or AC Ratio Option 11.

CAUTION

Adjustment of internal reference voltages per paragraph 3.8.6 will invalidate any previous calibration of the instrument. These adjustments, if needed, must be performed prior to other calibrations.

3.8.6.1 Remove Calibration Module cover and install AC Ratio/4-Wire DC Ratio bypass card (410764) in J305 and J306. This bypass card is dual-purpose with bypass connections for J305 on one end and J306 at the opposite end.

3.8.6.2 Install calibration cover on Calibration Module. apply power and allow at least one hour warmup.

3.8.6.3 Select DC External Reference (SHIFT, HDW, DC) and 10V range on keyboard.

3.8.6.4 Connect a DC Voltage Calibrator to the EXT REF terminals. Connect the 5 1/2 digit test DVM (positive lead) to TP2 on Attenuator/Reference board, and the negative lead to Gnd pin (Mecca) on Motherboard (near Non-Volatile Memory PCB bracket.)

3.8.6.5 Apply +1.00000 VDC to the EXT REF terminals. Adjust R5 on 10V Reference Assembly for 1.00000V ± 20 μV. Move the test DVM positive lead from TP2 to TP5. Adjust R30 on Attenuator/Reference board for −1.00000 ± 20 μV on test DVM.

3.8.6.6 Select DC Function on Keyboard (take out of external reference mode). Move positive lead of test DVM from TP5 to TP2 and note the test DVM reading (approximately +10 VDC). Move the positive lead of test DVM from TP2 to TP5 and adjust R32 for the same numeric reading (disregard the polarity sign) as TP2 (± 500μV).

3.8.6.7 Repeat the procedures in paragraphs 3.8.6.5 and 3.8.6.6 as needed.

3.8.6.8 Select DC External Reference (SHIFT, HDW, DC) on Keyboard. Increase the EXT REF input to +10.0000 VDC. Note the test DVM reading at TP5 (approximately −10 VDC). Move the positive lead of the test DVM to TP2 and note the test DVM reading (approximately +10 VDC).

3.8.6.9 Select DC Function on Keyboard (take out of external reference mode). With the test DVM positive lead on TP2, adjust R4 on the 10V Reference Assembly for the same reading as TP2 in step 3.8.6.8 (± 100μV).

4.1 INTRODUCTION.

4.1 This section contains system operating examples for the Model 6000. Each example contains a statement of purpose, a sample program string and the device dependent messages required to program the instrument for the particular application. These examples were prepared using a Hewlett-Packard 9825 calculator connected to the Racal-Dana Model 6000 through the IEEE 488-1975 Standard Interface. Each example contains a program listing as printed by the calculator along with an explanation for each line of the program. If the 6000 is to be used with a Hewlett-Packard Model 9825 calculator, the programming presented in this section may be used directly and/or further modified to suit the users needs. If the programs are used directly, the programmer should check to make sure that the 6000's rear panel address switches are set for an address of "01" (see Section 3.4.5). Because the Model 6000 may be used with any controller which operates on the standard interface bus, the user may wish to prepare equivalent software for another controller device. In such case, the user should review the remote operating instructions to select and assemble appropriate operating statements for the controller ›e used.

4.1.2 In the first program sample, line zero of the program is rem 7 and the accompanying explanation indicates that this statement causes the Hewlett Packard 9825 calculator to send the remote message to all devices on the bus. This statement causes the 6000 to arm for remote operation.

4.1.3 Referring again to the first example, note that line 1 of the program printout contains the statement flt 6 and that the accompanying explanation indicates that this sets the floating decimal format. This may or may not be a feature or function of the controller in use and, since it is not an interface or device dependent message, use of an equivalent command is at the discretion of the programmer. Line 2 of the program shows the statement wrt 701,. The explanation indicates that this transmits the device listen address 01. The programmer should select the statement for the controller in use which causes it to transmit the listen address assigned to the 6000. Instructions for the address assignment of the Model 6000 are presented in paragraph 3.4.7. Table 3.11 shows the address switch setting, the talk and listen address characters and the data line binary code for each available decimal address of the instrument.

4.1.4 Line 2 of the first example also contains the program string (composed of the device dependent messages). The examples contained in this section are primarily presented to show the various combinations of device dependent messages required to accomplish the various remotely controlled measurement operations. Note that the program printout indicates the string of device dependent messages presented in the table directly above the program tape. This format is maintained for all of the examples.

4.1.5 Line 3 of the first example is the reply subroutine of the program, and instructs the 6000 to become a talker so it can transmit the measurement data. Line 3 also instructs the calculator to store the transmitted measurement data (in a register known as "Variable A") and to print the data on the program tape. The final line on the program printout is the measurement value –2.001795e01 (–20.0 dB).

NOTE

The Model 6000 will respond to commands written in either upper or lower case letters.

`6: wrt 701,"m2"`	Address device 01 (RD6000) as listener and writes device dependent message followed by a Carriage Return (CR) and Line Feed (LF) to device 01 (RD6000).
`7: red 701,B`	Address device 01 (RD6000) as a talker. Reads value into variable B from device 01 (RD6000).
`8: wrt 701,"m3"`	Address device 01 (RD6000) as listener and writes device dependent message followed by a Carriage Return (CR) and Line Feed (LF) to device 01 (RD6000).
`9: red 701,C`	Address device 01 (RD6000) as a talker. Reads value into variable C from device 01 (RD6000).
`10: wrt 701,"m4"`	Address device 01 (RD6000) as listener and writes device dependent message followed by a Carriage Return (CR) and Line Feed (LF) to device 01 (RD6000).
`11: red 701,D`	Address device 01 (RD6000) as a talker. Reads value into variable D from device 01 (RD6000).
`12: wrt 701,"m5"`	Address device 01 (RD6000) as listener and writes device dependent message followed by a Carriage Return (CR) and Line Feed (LF) to device 01 (RD6000).
`13: red 701,E`	Address device 01 (RD6000) as a talker. Reads value into variable E from device 01 (RD6000).
`14: prt A;prt B; prt C;prt D; prt E` `*6475`	Prints the values stored in variables A, B, C, D and E.
`9.999294e 00`	Answer: 9.9992 NULL
`0.000000e 00`	Answer: 0.0000 minimum value
`0.000000e 00`	Answer: 0.0000 average value
`0.000000e 00`	Answer: 0.0000 maximum value
`2.400000e 02`	Answer: 240 samples

›se emotely program the AC volts function with the MAM (minimum-average-maximum) function
‹o measure amplitude variations of a signal source over a 10 second time period.

am String: F2R5M1
M2
M3
M4
M5

:e Dependent Messages:

'e Code	Parameter
	AC volts Range 5 Clear and enable MAM Transmit MIN Transmit AVG Transmit MAX Transmit number of samples

```
0: rem 7
1: flt 6
2: wrt 701,"f2r5
 m1"
3: wait 10000
4: wrt 701,"m2"
5: red 701,A
6: wrt 701,"m3"
```

- 0: Sends remote message to all devices on the bus.
- 1: Sets floating decimal (scientific notation) format. Six places to the right of the decimal point, i.e., X.XXXXXXeXX.
- 2: Address device 01 (RD6000) as listener and writes device dependent message followed by a Carriage Return (CR) and Line Feed (LF) to device 01 (RD6000).
- 3: Tells the controller (HP9825) to wait 10 seconds before executing next instruction.
- 4: Address device 01 (RD6000) as listener and writes device dependent message followed by a Carriage Return (CR) and Line Feed (LF) to device 01 (RD6000).
- 5: Address device 01 (RD6000) as a talker. Reads value into variable A from device 01 (RD6000).
- 6: Address device 01 (RD6000) as listener and writes device dependent message followed by a Carriage Return (CR) and Line Feed (LF) to device 01 (RD6000).

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REPAIR REQUEST FORM

To allow us to better understand your repair requests, we suggest you use the following outline and include a copy with your instrument to be sent to your local Racal-Dana repair facility.

Model Number ________________ Options ________________ Date ____________

Serial Number ____________________ P. O.# ______________________________

Company Name ____

Address ____

City ______________________________ State ________ Zip Code ___________

Contact _______________________ Phone Number ___________________________

1. Describe, in detail, the problem and symptoms you are having.

____

____

2. If you are using your unit on the bus, please list the program strings used and the controller type, if possible. ____

____

3. List all input levels, and frequencies this failure occurs.

____

____

4. Indicate any repair work previously performed.

____

____

5. Please give any additional information you feel would be beneficial in facilitating a faster repair time. (I. E., modifications, etc.)

____

____

PUBLICATION NO. 980514

MAINTENANCE MANUAL

SERIES 6000 MICROPROCESSING DIGITAL MULTIMETER

RACAL-DANA

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WARRANTY

Within one year of purchase, Racal-Dana will repair or replace your instrument, at our option, if in any way it is defective in material or workmanship. The instrument must be returned to the country of purchase, unless prior arrangement has been made, and Racal-Dana Instruments will pay all parts and labor charges. Just call Racal-Dana Customer Service at (714) 859-8999 in U.S.A., (0703) 843265 in England, (1) 3-955-8888 in France, 06102-2861/2 in Germany or (02) 5062767, 5052686, or 503444 in Italy for assistance. We will advise you of the proper shipping address for your prepaid shipment. Your instrument will be returned to you freight prepaid.

PROPRIETARY NOTICE

FOR YOUR SAFETY

Before undertaking any maintenance procedure, whether it be a specific troubleshooting or maintenance procedure described herein or an exploratory procedure aimed at determining whether there has been a malfunction, read the applicable section of this manual and note carefully the **WARNING** and **CAUTION** notices contained therein.

The equipment described in this manual contains voltage hazardous to human life and safety and which is capable of inflicting personal injury. The cautionary and warning notes are included in this manual to alert operator and maintenance personnel to the electrical hazards and thus prevent personal injury and damage to equipment.

If this instrument is to be powered from the AC line (mains) through an autotransformer (such as a Variac or equivalent) ensure that the common connector is connected to the neutral (earthed pole) of the power supply.

Before operating the unit ensure that the protective conductor (green wire) is connected to the ground (earth) protective conductor of the power outlet. Do not defeat the protective feature of the third protective conductor in the power cord by using a two conductor extension cord or a three-prong/two-prong adaptor.

Maintenance and calibration procedures contained in this manual sometimes call for operation of the unit with power applied and protective covers removed. Read the procedures carefully and heed Warnings to avoid "live" circuit points to ensure your personal safety.

Before operating this instrument:

1. Ensure that the instrument is configured to operate on the voltage available at the power source. See Installation Section.

2. Ensure that the proper fuse is in place in the instrument for the power source on which the instrument is to be operated.

3. Ensure that all other devices connected to or in proximity to this instrument are properly grounded or connected to the protective third-wire earth ground.

If at any time the instrument:

- Fails to operate satisfactorily
- Shows visible damage
- Has been stored under unfavorable conditions
- Has sustained stress

It should not be used until its performance has been checked by qualified personnel.

ERRATA SHEET

October 1986

The following Racal-Dana Model 6000 part numbers have new FSC numbers and/or new manufacturers part numbers:

Racal-Dana Part Number	FSC	Manu P/N
012098	91637	PTF56-T13
100017	56289	1C25Z5U103M100E
101145	56289	561CR3LBA102AF101J
110020	05397	T322D106K035AS
110125	05397	T355C225M035AS
110126	05397	T355F685M035AS
110127	05397	T355D226M006AS
110129	05397	T355A104M035AS
110137	05397	T355A474M035AS
110139	05397	T355A224M035AS
110140	05397	T355F476M006AS
110141	05397	T355F226M016AS
110151	05397	T354G106M035AS
110152	05397	T355B474K050AS
110158	05397	T354K106M050M
110165	05397	T355A154K035AS
110181	05397	T354K146M035AS
130124	52763	311609-241
130127	52763	300324-52D
210074	50434	HPQDSP-411S
210079	50434	HLMP-3401
600912	79727	GF-323-0070
920790	27556	PWS2142FL

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5.1 INTRODUCTION.

5.1.1 This section presents the theory of operation for the Model 6000 Microprocessing Digital Multimeter (DMM). The operation is analyzed first in terms of a basic block diagram (Figure 5.1) and then operating modes and individual circuits are described. The drawings in this section are provided for use in conjunction with the descriptions and as supplements to the complete schematics located in Section 7.

5.2 BASIC OPERATION.

5.2.1 As may be seen in Figure 5.1, the Model 6000 is composed of three major sections: Analog Signal Conditioner, Digital Control and Interface (optional). Input signals are conditioned and digitized in the Analog Signal Conditioner. Circuit timing and control signals are developed by the microprocessor based logic in the Digital Control section. The Digital Control section also provides keyboard decoding and display logic.

5.2.2 The Model 6000 may also be used as part of an instrumentation system. Remote control of the DMM is achieved through the use of one of the optional interface modules. As can be seen in Figure 5.1, the Interface acts as a bi-directional port for data and control signals generated by the Digital Control section and the external System Controller.

5.3 ANALOG SIGNAL CONDITIONER.

5.3.1 The following paragraphs present a detailed analysis of the signal conditioning process. A block diagram of the Analog section may be found in Figure 5.2.

5.3.2 The Analog section of the basic Model 6000 contains the following plug-in boards:

- Digitizer (J6)
- Isolator (J7)
- Switching (J9)
- Ohms Bypass (J8)
- Preamplifier Bypass (J10)
- Attenuator/Reference (J301, J302, J308)

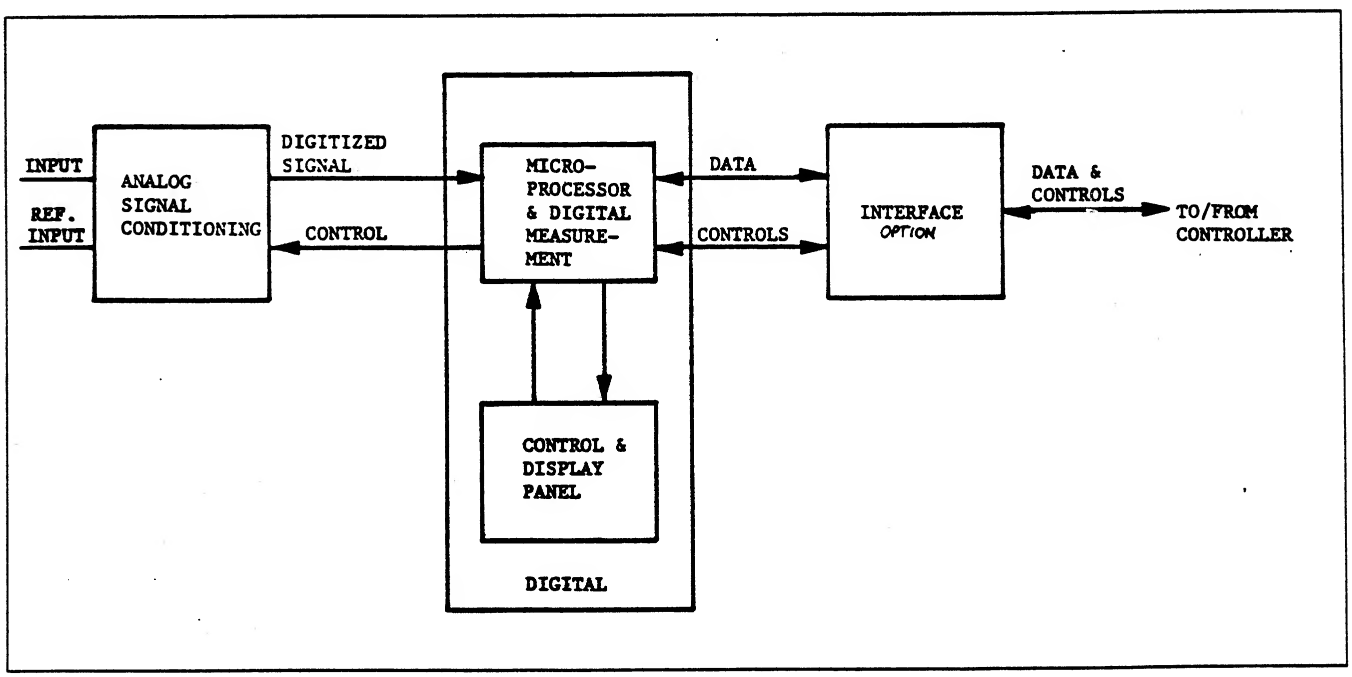


Figure 5.1 - Overall Block Diagram

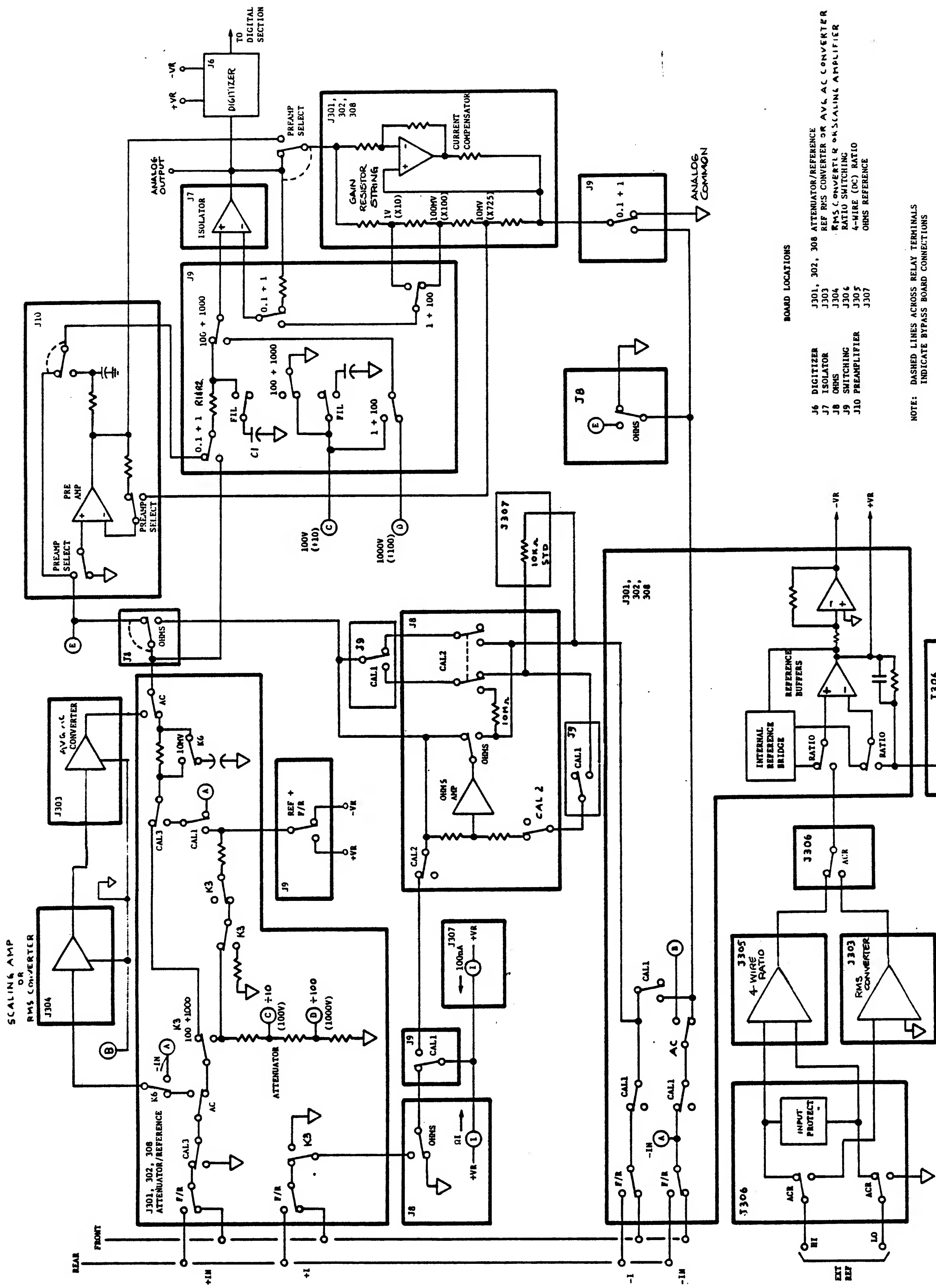


Figure 5.2 - Analog Section Block Diagram

5.3.3 The functional capabilities of the Analog section may be enhanced by the addition of the following optional plug-in boards:

- AC RMS Converter (J304)
- AC Averaging Converter and Scaling Amplifier (J303, J304)
- Ohms (Replaces Ohms Bypass) and Ohms Reference (J8, J307)
- Preamplifier (Replaces Preamplifier Bypass) (J10)
- Fast Waveform Digitizer (J5)
- Four Wire Ratio and Ratio Switching (For DC External Reference) (J305, J306)
- AC RMS Converter and Ratio Switching (For AC External Reference) (J303, J306)

NOTE

The AC External Reference option cannot be installed in an instrument containing an AC Averaging Converter.

5.3.3.1 For the convenience of the user during maintenance or field installation of options, the Model 6000 has an option label affixed to the transformer cover on the rear panel. It indicates the location of all option assemblies for that unit.

Option	Function	Location of Unique Assy
—	AC rms	Cal Module
—	488 Interface	Mainframe
—	Ohms	Cal Mod./Mainfr.
03SH	H.S. Digitizer	Mainframe
04	50 Hz line	Mainframe
09	Ratio Switch	Cal Module
11	Ref AC rms	Cal Module
14	AC avg	Cal Module
34	4W Ratio	Cal Module
41	10mV/1Ω	Mainframe
59	BCD Interface	Mainframe
60	Rack Mount	Mainframe
66	Slide Mount	Mainframe
71	220/240 line	Mainframe

5.3.4 Measurement Modes.

5.3.4.1 The Model 6000 (with the appropriate options) is capable of measuring DC voltage, AC voltage and resistance. The DMM is also capable of accepting external references in the measurement process, ratio measurements and automatic self-calibration.

5.3.4.2 The route a measurement signal follows through the analog section depends on the functions and ranges selected. Functions and ranges are selected by either the use of the front panel controls or by external commands received at the interface. Signal flow diagrams in Section 6 show the routing of measurement signals for different functions and ranges of the DMM.

NOTE

Inputs may be applied to the front panel and/or rear panel input terminals. Selection of the input(s) for measurement is made by either the use of the front panel controls or by external commands received at the interface.

5.3.4.3 DC VOLTAGE MEASUREMENT.

5.3.4.3.1 The basic Model 6000 is capable of measuring DC voltage in five ranges: 100 mV, 1V, 10V, 100V and 1000V. A 10 mV range is also available when the instrument is equipped with a Preamplifier (Option 41).

5.3.4.3.2 DC signal inputs may be traced from the selected +IN terminal through contacts of the F/R (Front/Rear), Cal 3 and AC relays (reference Figure 5.2). The path from the selected –IN terminal is routed through contacts of the F/R, Cal 1 and AC relays. Signal routing beyond these points is dependent upon range selection.

5.3.4.3.3 *10 Volt Range.* The signal from the +IN terminal is routed through the contacts of the 100+1000, Ohms, Preamp Select, .1+1 and 100+1000 relays to the positive input of the Isolator. The Isolator output is fed back directly to the negative input (through the normally closed contacts of the .1+1 relay) to obtain a closed loop gain of 1.0. The –IN terminal is connected to analog common through contacts of the Ohms relay. A simplified block diagram is shown in Figure 5.3.

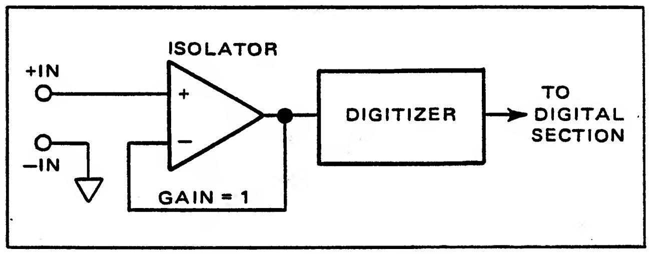


Figure 5.3 - 10 Volt DC Range

5.3.4.3.4 *1 Volt Range.* The signal from the +IN terminal is routed through the contacts of the .1+1 relay to the positive input of the Isolator. The Isolator output is applied to the Gain Resistor string through the normally closed contacts of the Preamp Select relay. A feedback signal from the Gain Resistor string is applied to the negative input of the Isolator (through the normally open contacts of the 1+100 and .1+1 relays) to obtain a closed loop gain of 10. The –IN terminal is connected to analog common through contacts of the Ohms relay, and to the lower end of the Gain Resistor string through contacts of the .1+1 relay. A simplified block diagram is shown in Figure 5.4.

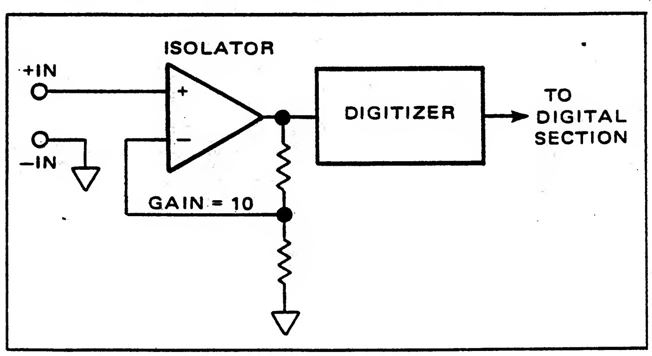


Figure 5.4 - 1 Volt DC Range

5.3.4.3.5 *100 Millivolt Range.* The signal from the +IN terminal is routed through the contacts of the .1+1 relay to the positive input of the Isolator. The Isolator output is applied to the Gain Resistor string through the normally closed contacts of the Preamp Select relay. A feedback signal from the Gain Resistor string is applied to the negative input of the Isolator (through the normally closed contacts of the 1+100 relay and the normally open contacts of the .1+1 relay) to obtain a closed loop gain of 100. The –IN terminal is connected to analog common through contacts of the Ohms relay, and to the lower end of the Gain Resistor string through contacts of the .1+1 relay. A simplified block diagram is shown in Figure 5.5.

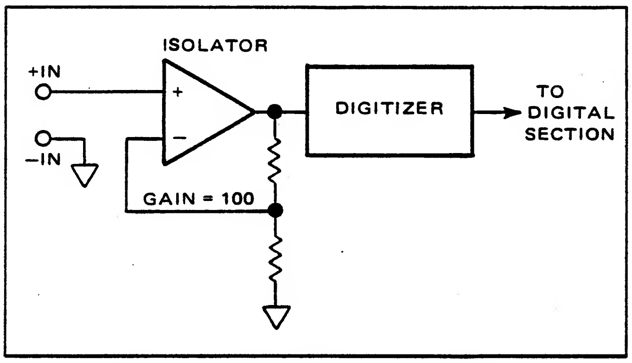


Figure 5.5 - 100 Millivolt DC Range

5.3.4.3.6 *100 and 1000 Volt Ranges.* The signal from the +IN terminal is routed through contacts of the Attenuator/ Reference board 100+1000 relay to the attenuator. The attenuator scales down the input signal by a factor of 10 (100 volt range) or 100 (1000 volt range). The attenuated signal is routed through the contacts of the 1+100 and 100+1000 relays to the positive input of the Isolator. The Isolator output is fed back directly to the negative input (through the normally closed contacts of the .1+1 relay) to obtain a closed loop gain of 1.0. The –IN terminal is connected to analog common through contacts of the Ohms relay. A simplified block diagram is shown in Figure 5.6.

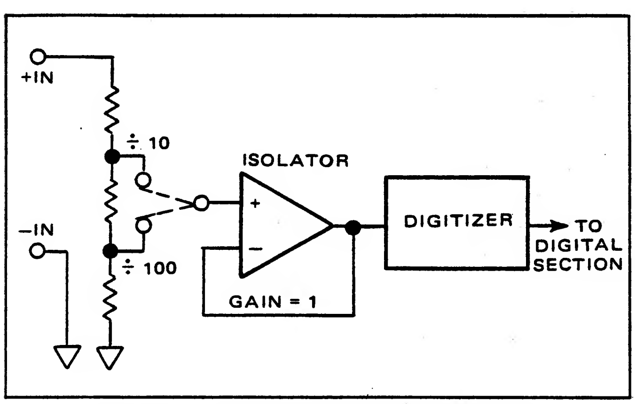


Figure 5.6 - 100 and 1000 Volt DC Ranges

5.3.4.3.7 *10 Millivolt Range (Option 41).* The signal from the +IN terminal is routed through the contacts of the 10 mV and Preamp Select relays to the positive input of the Preamplifier. The filtered output of the Preamplifier is fed through contacts of the Preamp Select and .1+1 relays to the positive input of the Isolator. The unfiltered output of the Preamplifier is fed through contacts of the Preamp Select relay to the Gain Resistor string. A feedback signal from the Gain Resistor string is applied to the negative input of the Preamplifier (through the contacts of the Preamp Select relay) to obtain a Preamplifier gain of 725. The Isolator output is fed back directly to the negative input (through the normally closed contacts of the .1+1 relay to obtain a closed loop gain of 1.0. The –IN terminal is connected to analog common through contacts of the Ohms relay. A simplified block diagram is shown in Figure 5.7.

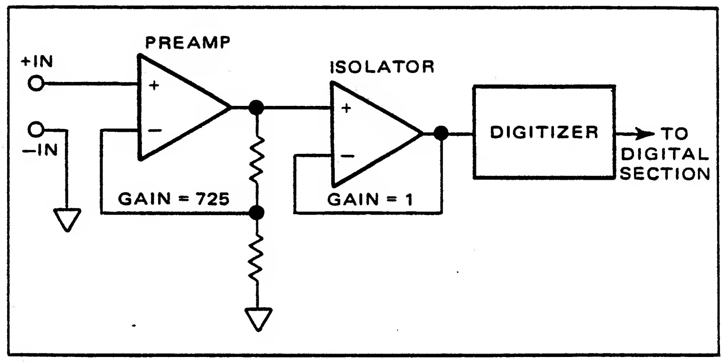


Figure 5.7 - 10 Millivolt DC Range

5.3.4.3.8 The full scale Isolator output of 7.25 volts (for a 10 mV input) is scaled by the Microprocessor to display a full scale reading. The scaling process allows for an overrange of 120% (22 mV input and 16 volt Isolator output).

5.3.4.4 AC VOLTAGE MEASUREMENT (OPTIONS 10 AND 14).

5.3.4.4.1 The Model 6000 (when equipped with Option 10 or Option 14) is capable of measuring AC voltage in four ranges: 1V, 10V, 100V and 1000V. Option 10 provides the DMM with a True RMS Converter. Option 14 provides the DMM with a Scaling Amplifier (J304) and an Averaging Converter (J303).

5.3.4.4.2 AC signal inputs may be traced from the selected +IN terminal through contacts of the F/R (Front/Rear), Cal 3, AC and K6 relays to the input of the AC Converter (Option 10 or Option 14). The output of the AC Converter is routed through contacts of the AC, .1+1 and 100+1000 relays to the positive input of the Isolator. The output of the AC Converter is 1.0 VDC full scale (independent of range selection) and the Isolator output is applied to the

Gain Resistor string for a closed loop gain of 10. The path from the −IN terminal is routed through contacts of the F/R, Cal 1 and AC relays to analog common. A simplified block diagram is shown in Figure 5.8.

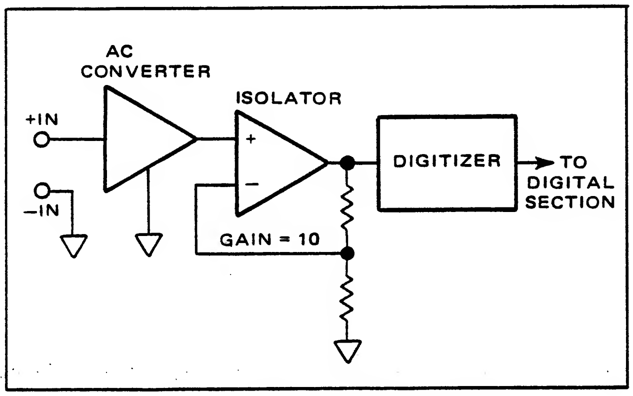


Figure 5.8 - AC Voltage Measurement

5.3.4.5 OHMS MEASUREMENT (OPTION 24).

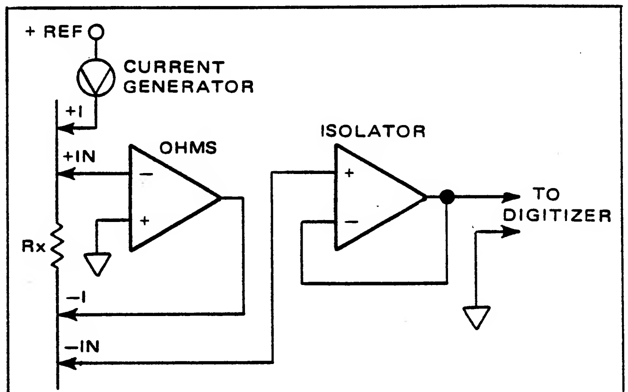
5.3.4.5.1 The Model 6000 (when equipped with Option 24) is capable of measuring resistance in eight ranges: 10Ω, 100Ω, 1KΩ, 10KΩ, 100KΩ, 1MΩ, 10MΩ, and 100MΩ. A 1Ω range is also available when the instrument is equipped with a Preamplifier (Option 41).

5.3.4.5.2 The circuit configuration is dependent upon the range selected and may take one of three forms. Figures 5.9 - 5.11 show simplified block diagrams of these configurations. In each of the configurations, a current reference is applied to the resistance being measured. This resistance is connected as the feedback path for the Ohms amplifier and the current through this resistance will equal the current provided by the current reference. The output of the Ohms amplifier is a negative DC voltage proportional to the resistance being measured.

5.3.4.5.3 *10KΩ - 100MΩ Ranges.* As shown in Figure 5.9, the output of the Ohms Amplifier is applied to the positive input of the Isolator. The Isolator has a closed loop gain of 1.0 in these ranges, and serves as a buffer between the Ohms amplifier and the Digitizer. The full scale output of the Ohms Amplifier and Isolator is −10 volts.

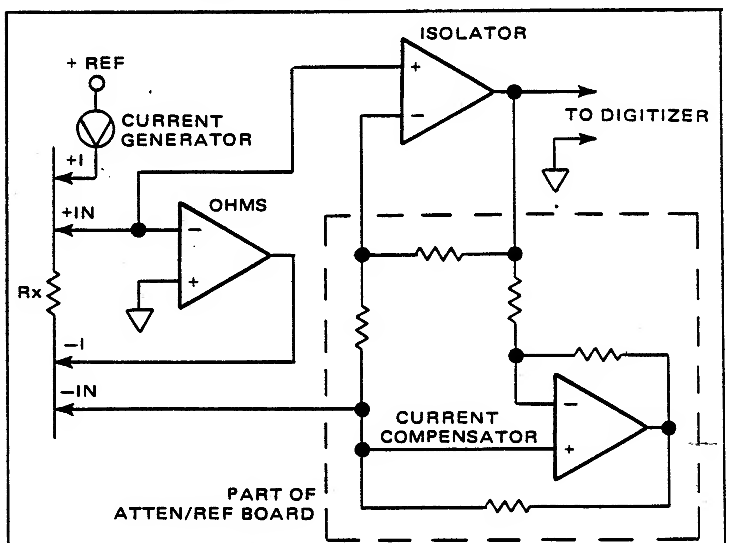
5.3.4.5.4 *10Ω - 1KΩ Ranges.* As shown in Figure 5.10, the output of the Ohms amplifier is applied to the positive input of the Current Compensator, and to the negative input of the Isolator (through part of the Gain Resistor string). The output of the Current Generator is applied to the positive input of the Isolator. In this configuration, the output of the Ohms amplifier is inverted and amplified by the Isolator for a full scale output of +10 volts. Isolator gain is 100 in the 10Ω range and 10 in the 100Ω and 1KΩ ranges.

The Current Compensator keeps the current through the Gain Resistor string from flowing through the resistance being measured.



RANGE	CURRENT	FULL SCALE OUT
10KΩ	1mA	
100KΩ	100μA	
1MΩ	10μA	−10V
10MΩ	1μA	
100MΩ	100nA	

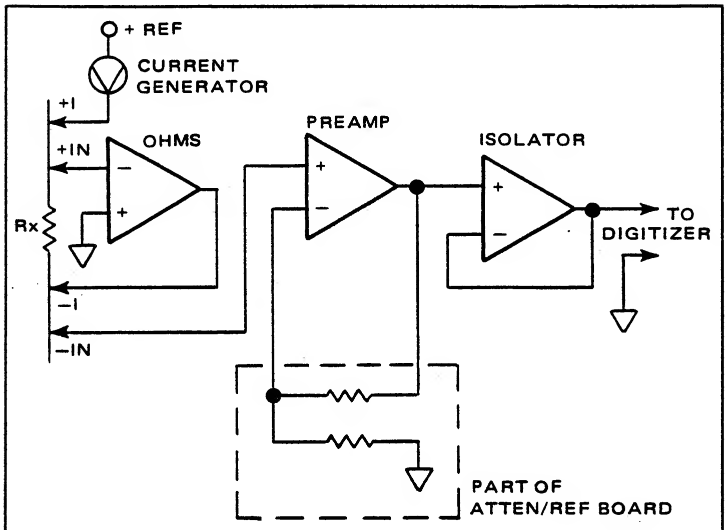
Figure 5.9 - 10KΩ - 100MΩ Ranges



RANGE	CURRENT	FULL SCALE OUT
10Ω	10mA	
100Ω	10mA	+10V
1KΩ	1mA	

Figure 5.10 - 10Ω - 1KΩ Ranges

5.3.4.5.5 *1Ω Range (Option 41).* As shown in Figure 5.11, the output of the Ohms amplifier is applied to the positive input of the Preamplifier (Option 41). The Preamplifier provides a gain of 725 and the output is applied to the positive input of the Isolator. The Isolator has a closed loop gain of 1.0 and serves as a buffer between the Preamplifier and the Digitizer. The full scale output of the Preamplifier and Isolator is −7.25 volts.



RANGE	CURRENT	FULL SCALE OUT
1Ω	10mA	−7.25V

Figure 5.11 - 1Ω Range

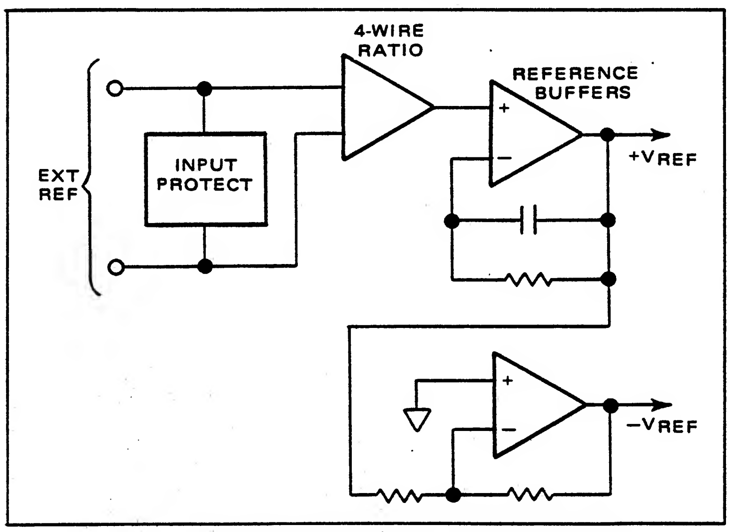


Figure 5.12 - External Reference (DC EXT REF)

5.3.4.6 EXTERNAL REFERENCES AND HARDWARE RATIO.

5.3.4.6.1 Hardware ratio measurements are performed by replacing the internal reference voltages with an external reference. The external reference voltage is applied to the EXT REF terminals and may be either AC (Option 11) or DC (Option 34). Signal voltages applied to the front or rear input terminals of the DMM are divided by the external reference voltage.

5.3.4.6.2 The Model 6000 will accept DC external reference voltages between +1.0 and +10.5 volts when DC EXT REF is selected. As shown in Figure 5.2, the external reference voltage is routed through the normally closed contacts of the ACR relay to the differential inputs of the 4-Wire Ratio amplifier. The 4-Wire Ratio amplifier acts as a buffer, and eliminates ground loop errors by permitting the reference voltage to float with respect to the input signal common. The output of the 4-Wire Ratio amplifier is routed through the normally closed contacts of the ACR relay and the normally open contacts of the Ratio relay to the input of the Reference Buffers. The Reference Buffers are unity gain amplifiers, and provide plus and minus reference voltages equal in magnitude to the external reference voltage. A simplified block diagram is shown in Figure 5.12.

5.3.4.6.3 External reference voltages from 0.1 to 1000 volts AC or DC can be used when AC EXT REF or DC coupled AC EXT REF is selected. The high side of the external reference voltage is routed through the normally open contacts of the ACR relay to the input of the RMS Converter. Note that the low side of the external reference voltage is connected to analog common through the ACR relay, thus the reference voltage does not float with respect to the input signal voltage. The RMS Converter scales and takes the true RMS value of the external reference voltage. The +1.0 volt full scale output of the RMS Converter is routed through the normally open contacts of the ACR and Ratio relays to the input of the Reference Buffers. The Reference Buffers are set for a gain of 10 to produce ± 10 volts DC full scale reference voltages. A simplified block diagram is shown in Figure 5.13.

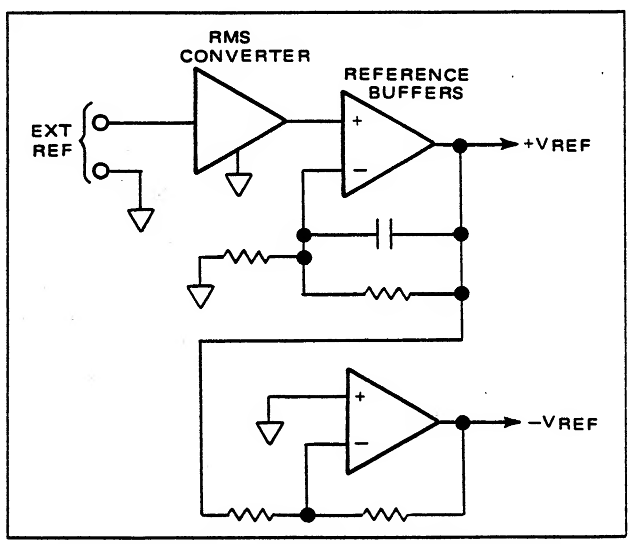
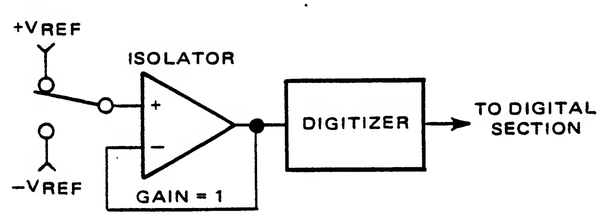


Figure 5.13 - External Reference (AC EXT REF)

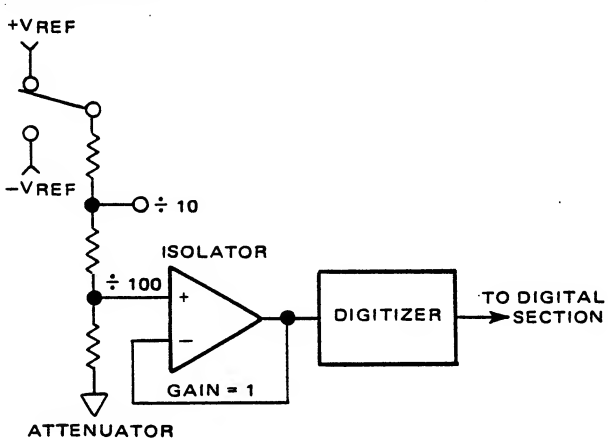
5.3.4.7 AUTO-CAL CONFIGURATIONS.

5.3.4.7.1 When the Auto-Cal routine is initiated, the Model 6000 sets the analog circuitry to various configurations, tests error factors against preset limits and, if the errors are within these limits, stores correction factors in memory. The basic Auto-Cal routine will perform seven DC test and calibration steps. The routine will also include five Ohms steps (if Option 24 is installed). One additional DC step and one additional Ohms step are performed when a Preamplifier (Option 41) is installed.

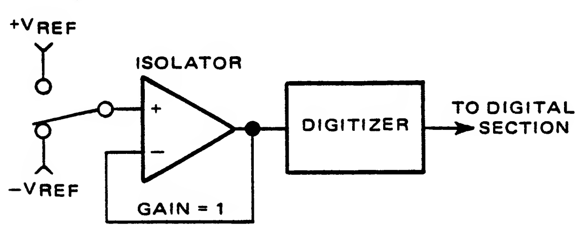
5.3.4.7.2 *DC CAL 1.* The Isolator/Digitizer configuration is calibrated with the positive reference voltage (see block diagram below).



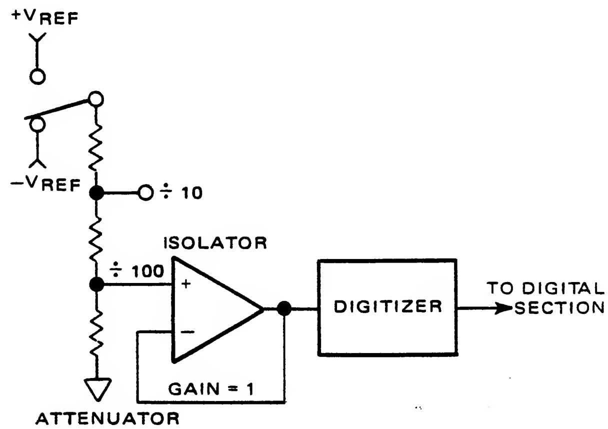
5.3.4.7.3 *DC CAL 2.* The Attenuator/Isolator/Digitizer configuration is calibrated with the positive reference voltage (see block diagram below).



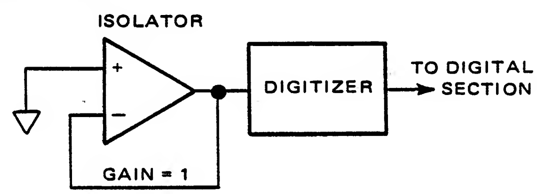
5.3.4.7.4 *DC CAL 3.* The Isolator/Digitizer configuration is calibrated with the negative reference voltage (see block diagram below).



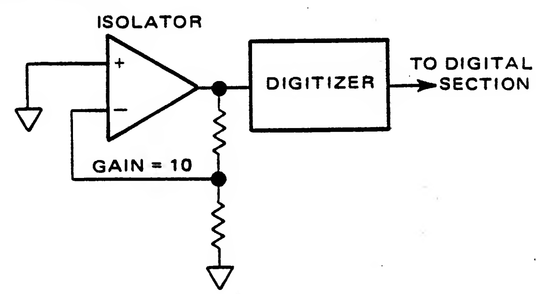
5.3.4.7.5 *DC CAL 4.* The Attenuator/Isolator/Digitizer configuration is calibrated with the negative reference voltage (see block diagram below).



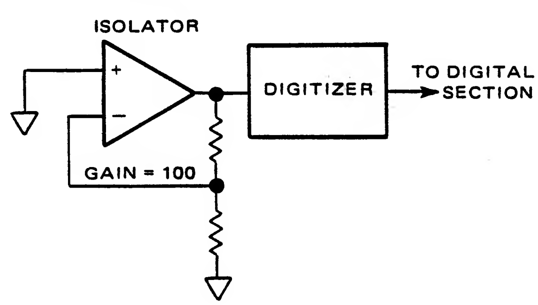
5.3.4.7.6 *DC CAL 5.* The offset of the Isolator/Digitizer configuration is measured in the 10 volt range (see block diagram below).



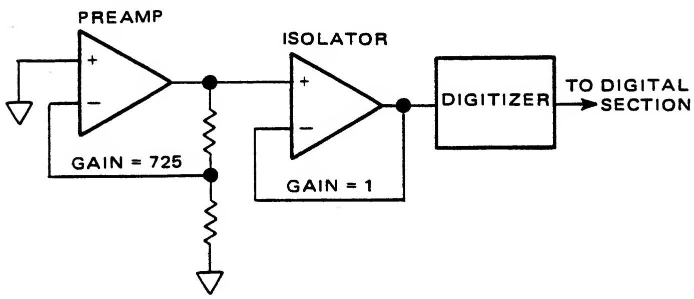
5.3.4.7.7 *DC CAL 6.* The offset of the Isolator/Digitizer configuration is measured in the 1 volt range (see block diagram below).



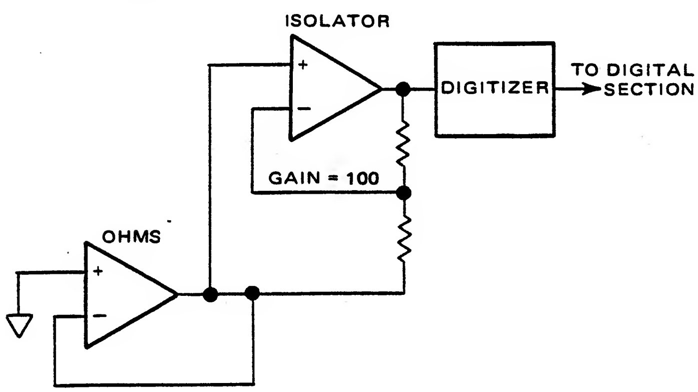
5.3.4.7.8 *DC CAL 7.* The offset of the Isolator/Digitizer configuration is measured in the 100 millivolt range (see block diagram below).



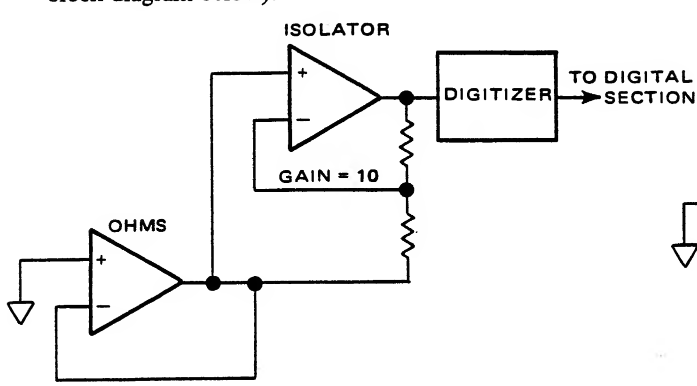
5.3.4.7.9 *DC CAL 8.* The offset of the Preamplifier/Isolator/Digitizer configuration is measured in the 10 millivolt range (see block diagram below).



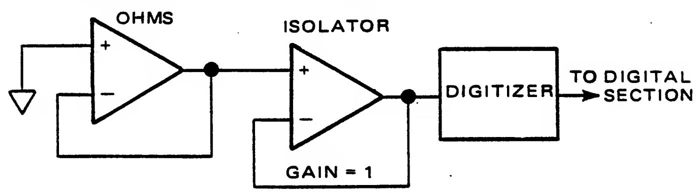
5.3.4.7.10 *Ohms CAL 1.* The offset of the Ohms/Isolator/Digitizer configuration is measured for the 10Ω range (see block diagram below).



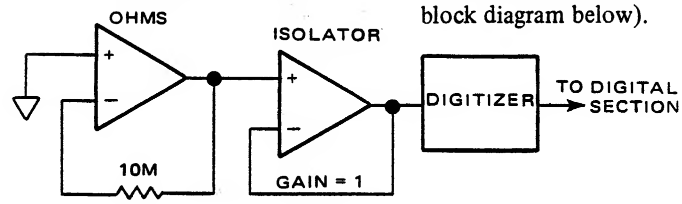
5.3.4.7.11 *Ohms CAL 2.* The offset of the Ohms/Isolator/Digitizer configuration is measured for the 100Ω range (see block diagram below).



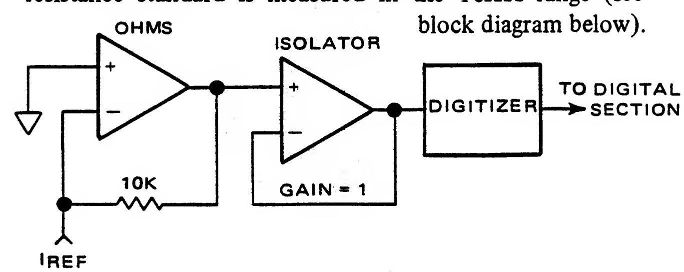
5.3.4.7.12 *Ohms CAL 3.* The offset of the Ohms/Isolator/Digitizer configuration is measured for the 10KΩ and higher ranges (see block diagram below).



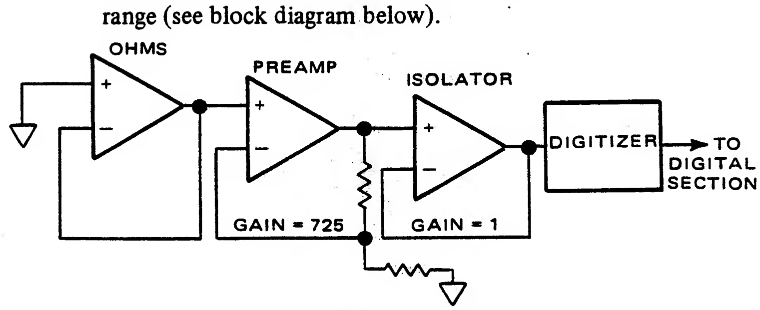
5.3.4.7.13 *Ohms CAL 4.* The offset due to input bias current is measured for the 10KΩ and higher ranges (see block diagram below).



5.3.4.7.14 *Ohms CAL 5.* The accuracy of the internal 10KΩ resistance standard is measured in the 10KΩ range (see block diagram below).



5.3.4.7.15 *Ohms CAL 6.* The offset of the Ohms/Preamplifier/Isolator/Digitizer configuration is measured for the 1Ω range (see block diagram below).



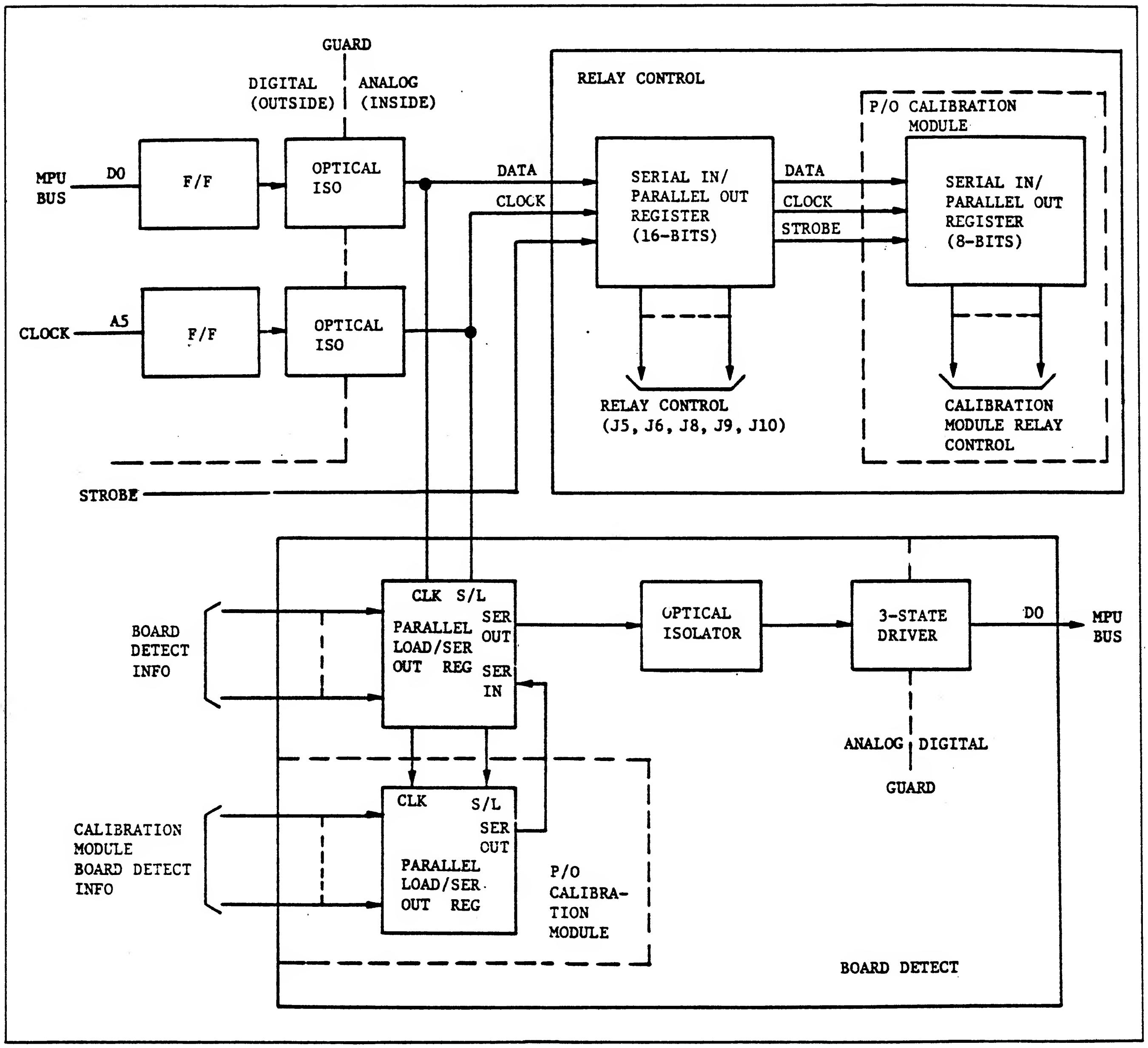


Figure 5.14 - Relay Control and Board Detect

5.3.5 Circuit Descriptions.

5.3.5.1 The following paragraphs contain descriptions of the circuitry and block diagrams of the circuit boards in the analog section. Detailed schematics may be found in Section 7.

5.3.5.2 MOTHERBOARD.

5.3.5.2.1 The Motherboard provides connectors for the insertion of the printed circuit boards (analog and digital), interconnections between the circuit boards, and power supplies. The Motherboard also contains the board detection logic and the control circuitry for the Switching Board relays.

5.3.5.2.2 *Power Supply.* AC line voltage is routed through front panel switch S101 to transformer T201. The secondary voltages are rectified, filtered and regulated to provide the required DC voltages. The digital half of the supply provides three +5 volt supplies and a –30 volt supply. The analog half of the supply is located inside of the guard area and produces regulated voltages of +5 volts, +15 volts, +24 volts, –15 volts and –24 volts. An unregulated voltage of –40 to –85 volts (labeled –40V) is generated for use in the Digitizer. Unregulated ± 30 volts is supplied to the Isolator.

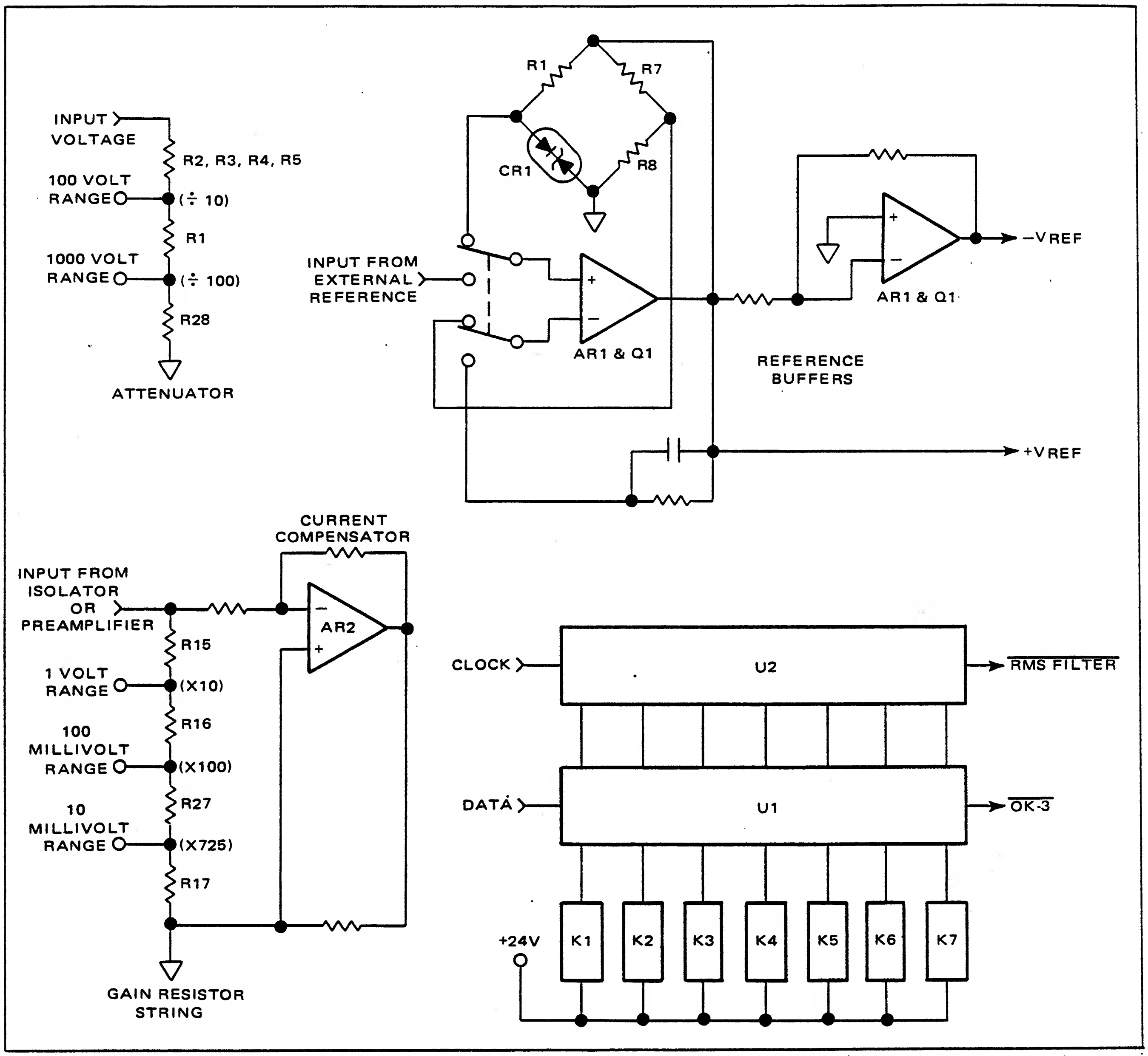


Figure 5.15 - Attenuator/Reference Board Block Diagram

5.3.5.2.3 *Relay Control Circuitry.* The relay control circuitry (Figure 5.14) consists of two flip-flops (U6), two opto-isolators, two serial to parallel shift registers (U4 and U9) and twelve relay drivers (U5 and U6). Control bits from the microprocessor are clocked through U6 and the opto-isolators and into the shift registers. The shift register outputs are buffered by the relay drivers.

5.3.5.2.4 *Board Detection Logic.* The board detection logic (Figure 5.14) consists of two parallel to serial shift registers (U2 on the Motherboard and U1 in the Cal Module) and an opto-isolator. After the relay control bits are loaded into U4 and U9, the clock and data lines from the microprocessor are used to load the board detection shift registers. The bits are then shifted out of the registers and to the microprocessor through the opto-isolator. The microprocessor uses the information to determine which functions, ranges and Auto-Cal procedures may be performed by the instrument.

5.3.5.3 SWITCHING BOARD.

5.3.5.3.1 The Switching Board contains relays, controlled by the microprocessor and the relay control logic on the Motherboard, which provide selection and routing for input signals. The Switching Board also provides one pole of the

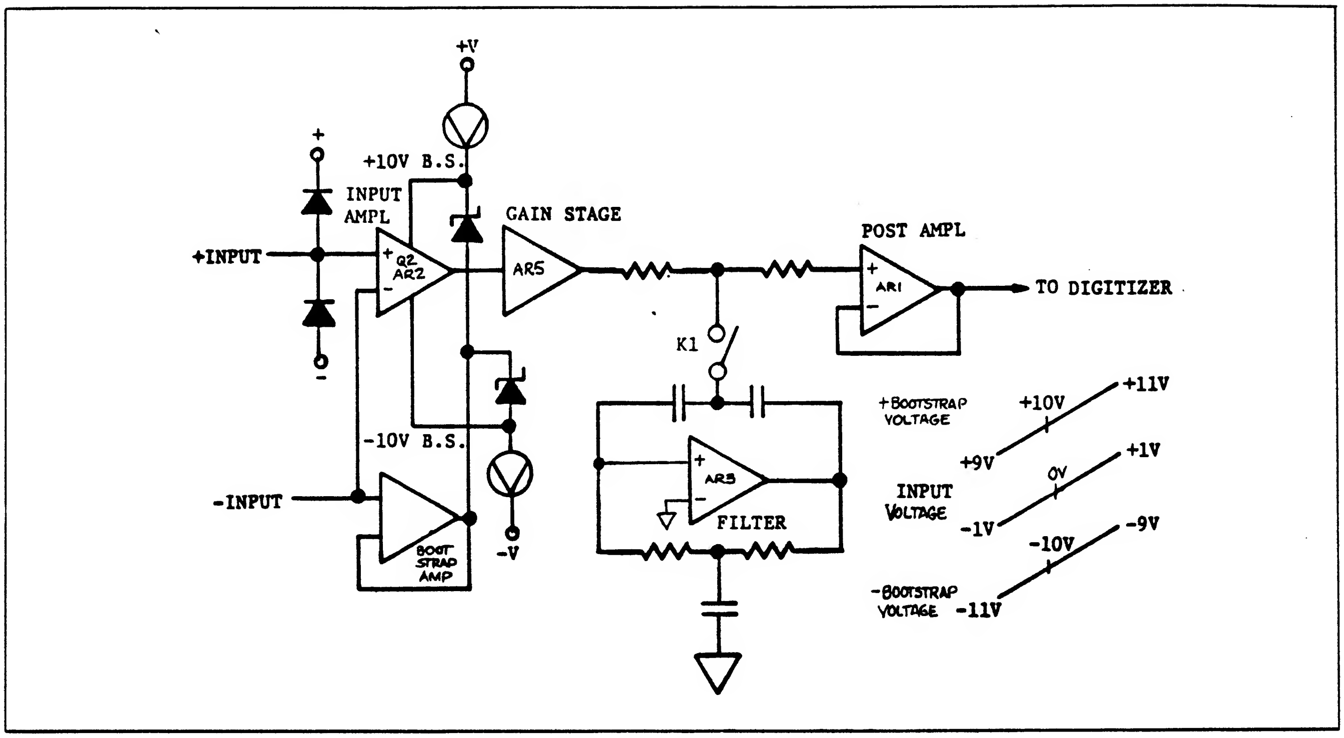


Figure 5.16 - Isolator Block Diagram

switchable 4-pole active filter at the input of the Isolator. The RC network of R1, R2 and C1 provide filtering in all functions and ranges except the 100 and 1000 volt DC ranges. Filtering in the 100 and 1000 volt DC ranges is provided by C2 in conjunction with the attenuator resistors. The other three poles of the active filter are provided in the Isolator.

5.3.5.4 ATTENUATOR/REFERENCE BOARD.

5.3.5.4.1 The Attenuator/Reference Board (Figure 5.15) provides a signal attenuation network, a gain resistor network and reference voltage circuitry. The Attenuator/Reference Board also contains on-board relays and relay control logic.

5.3.5.4.2 *Attenuator.* The signal attenuation network is a resistor voltage divider comprised of R1 through R5 and R28. The input signal is attenuated by a factor of 10 in the 100 volt DC range and by a factor of 100 in the 1000 volt DC range.

5.3.5.4.3 *Gain Resistor Network.* The gain of the Isolator and Preamplifier is set by the feedback resistors in the gain resistor network. The resistor network (R15, R16, R17 and R27) provides Isolator gains of 1, 10 and 100, and a Preamplifier gain of 725. Operational amplifier AR2 provides current compensation for the low ohms ranges.

5.3.5.4.4 *Voltage Reference.* The voltage reference circuitry provides internal references of +10 volts and −10 volts or positive and negative reference voltages proportional to an external reference. The internal reference is developed by a reference bridge comprised of R1, R7, R8 and CR1 on the Reference Assembly.

5.3.5.4.5 The selected reference voltage (internal or external) is routed to the inputs of operational amplifier AR1 on the 10 Volt Reference Board. The positive reference is applied to the DMM through current amplifier Q1. Operational amplifier AR1 and transistor Q1 on the Attenuator Board derive the minus reference voltage from the positive reference.

5.3.5.5 ISOLATOR BOARD.

5.3.5.5.1 The Isolator (Figure 5.16) consists of a high open loop gain amplifier, a bootstrap amplifier and three poles of the switchable 4-pole active filter. The Isolator is connected in a potentiometric gain configuration with feedback resistors located on the Attenuator/Reference Board. Gains of 1, 10 or 100 are provided by the Isolator, depending on the range and function selected.

5.3.5.5.2 *Bootstrap Amplifier.* The bootstrap amplifier (Q5, Q6, Q7 and operational amplifier AR4) generates bootstrap voltages of approximately +10 volts DC and −10 volts

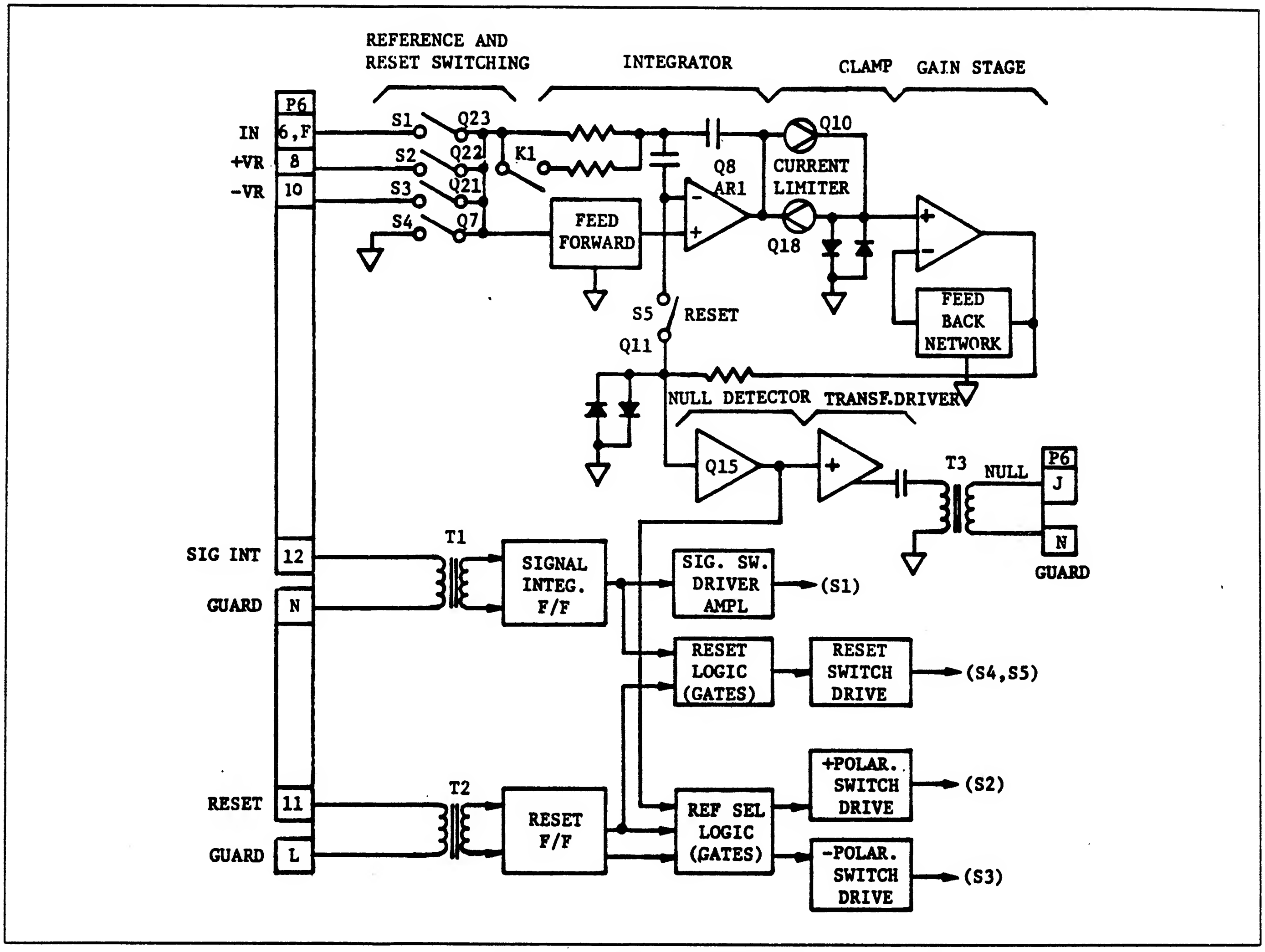


Figure 5.17 - Digitizer Block Diagram

DC when the input to the Isolator is 0 volts DC. As the input voltage increases in the positive direction, both of the bootstrap voltages also increase an equal amount in the positive direction. As the input moves in the negative direction, both of the bootstraps move an equal amount in the negative direction. This bootstrap effect provides an effective input impedance greater than 10,000 megohms. Figure 5.16 illustrates the relationship.

5.3.5.5.3 *Forward Gain Stages.* Isolator gain stages are provided by Q2 and operational amplifiers AR2, AR5 and AR1. Input over-voltage protection is provided by Q1, Q3, Q8, Q9 and CR5 through CR7.

5.3.5.5.4 *Active Filter.* The switchable filter is an active 3-pole Bessel type formed by operational amplifier AR3. The filter is connected by relay K1 ahead of the final section of the gain stage (AR1).

5.3.5.6 DIGITIZER BOARD.

5.3.5.6.1 The Digitizer (Figure 5.17) performs the analog to digital conversion in the DMM. The circuitry includes integration circuitry, a switching network, gain stage, null detection and signal and reset logic.

5.3.5.6.2 *Integrator.* The Integrator consists of an operational amplifier (AR1 and Q8) with a capacitive feedback path to convert the DC levels applied at the input to a corresponding ramp voltage at the Integrator output. The use of a dual FET input stage (Q8) provides for a high input impedance, permits capacitor input coupling during the integration period and allows for auto-zeroing during reset. The feed forward circuitry is a voltage divider network (R15 through R17 and C4) that applies a portion of the reference voltage to the non-inverting input of the Integrator during the reference integration period. This causes an equal amount of voltage to appear at the output.

5.3.5.6.3 *Input Switches.* The input switching is performed by junction FET's (Q21 through Q23, Q7, Q11 and Q16). At the beginning of the signal integration period, a positive pulse is applied to T1, causing Q1 of the input switching flip-flop to conduct. Q1, in turn, causes the signal input switch (Q23) to apply the input signal to the Integrator. Relay K1-A is energized in the 4 1/2 and 5 1/2 digit modes, placing R14 in parallel with R13, thus decreasing the input time constant and the total integration period. The integration periods are: 100 msec to ramp to 10 volts (6 1/2 digit), 16.67 msec to ramp to 10 volts (5 1/2 digit) and 1.67 msec to ramp to 1 volt (4 1/2 digit).

5.3.5.6.4 At the end of the signal integration period, a negative pulse is applied to T1, causing Q1 to turn off and Q2 to turn on. This change of state causes switch Q23 to open and either Q21 or Q22 to close. The selection of the appropriate reference voltage is determined by the output of the polarity switch drive flip-flop (U1 and U2). The flip-flop state is set by a pulse from the null detector circuitry (negative pulse for positive input and positive pulse for negative input). The Integrator will integrate the positive reference when there is a negative input signal and the negative reference when there is a positive input signal.

5.3.5.6.5 The end of the reference integration period occurs when the Null Detector detects an axis crossing and changes state. When a reset pulse is applied to T2, Q4 is turned on and Q3 is turned off. Both of the polarity switch drive flip-flop outputs are set high, which holds both reference switches (Q21 and Q22) open. The reset signal also closes reset switches Q7, Q11 and Q16. Integration timing is shown in Figure 5.18.

5.3.5.6.6 *Gain Stage.* The gain circuitry (Q36, Q30, Q29, Q35, Q17 and Q9) amplifies the output from the Integrator (particularly in the area near zero) to provide a clearly defined axis crossing signal for the null detecting circuitry. The gain stage also exhibits low pass filter characteristics which adds to the total delay of the integration sequence. The added delay reduces the noise response of the system and reduces the wide band response requirements of the Null Detector. The gain circuitry comprises an inverting potentiometric amplifier with programmed gain control. The amplifier provides a gain of 300 for stage inputs up to 13 mV and a gain of 14 for signals above 13 mV.

5.3.5.6.7 *Null Detector.* The Null Detector (Q14 and Q15) is an inverting, closed-loop amplifier with an output swing of five volts. The analog signal from the Integrator is converted to a TTL compatible digital signal, and the logic level of this signal sets the state of the polarity switch drive flip-flop. Output driver Q12 and Q13 and transformer T3 couple the Null Detector output pulse to the Digital Control section of the DMM.

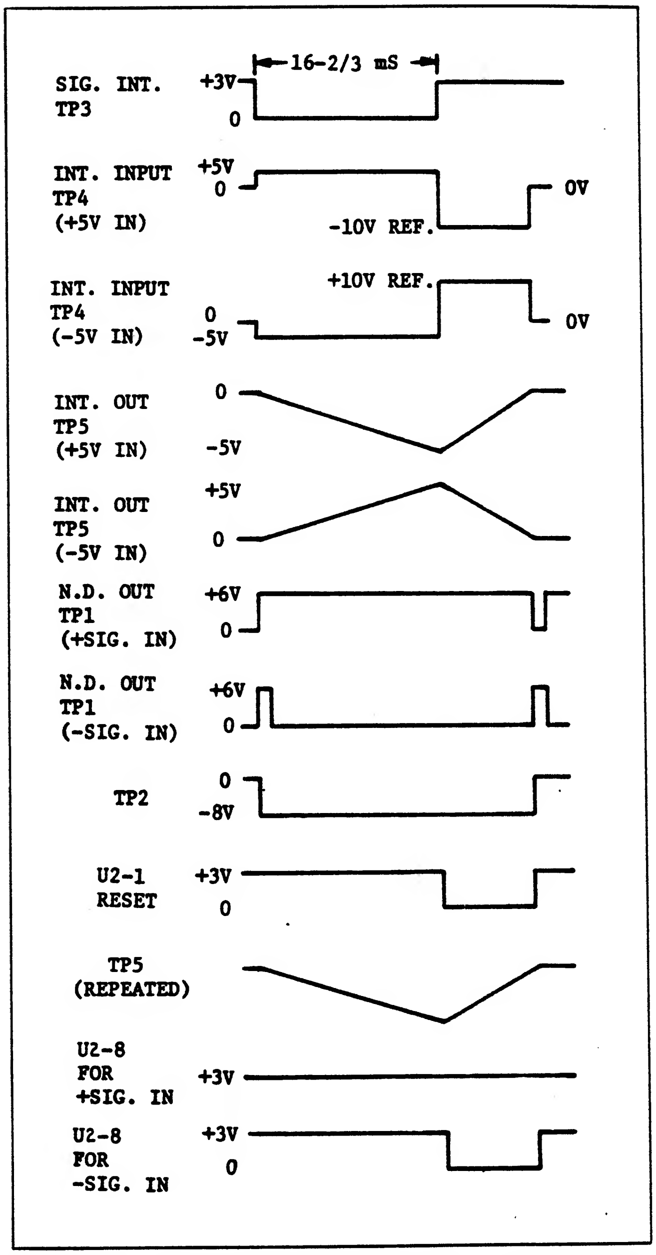


Figure 5.18 - Integration Timing Diagram, 5 1/2 Digit Mode

5.3.5.7 PREAMPLIFIER BOARD (OPTION 41).

5.3.5.7.1 The Preamplifier (Figure 5.19) provides a signal gain of 725 in the 10 mV and 1Ω ranges. The circuitry consists of a modulator, demodulator, oscillator, integrating amplifier and AC amplifier.

5.3.5.7.2 The input signal is routed through the input filter and input clamp to the modulator (Q8 and Q9). The modulator (chopped by the 400 Hz signal from the oscillator of Q8 and Q9) compares the input signal with the Preamplifier feedback signal. The feedback signal is routed from the output of AR1, through K1-A, the gain resistor string (on

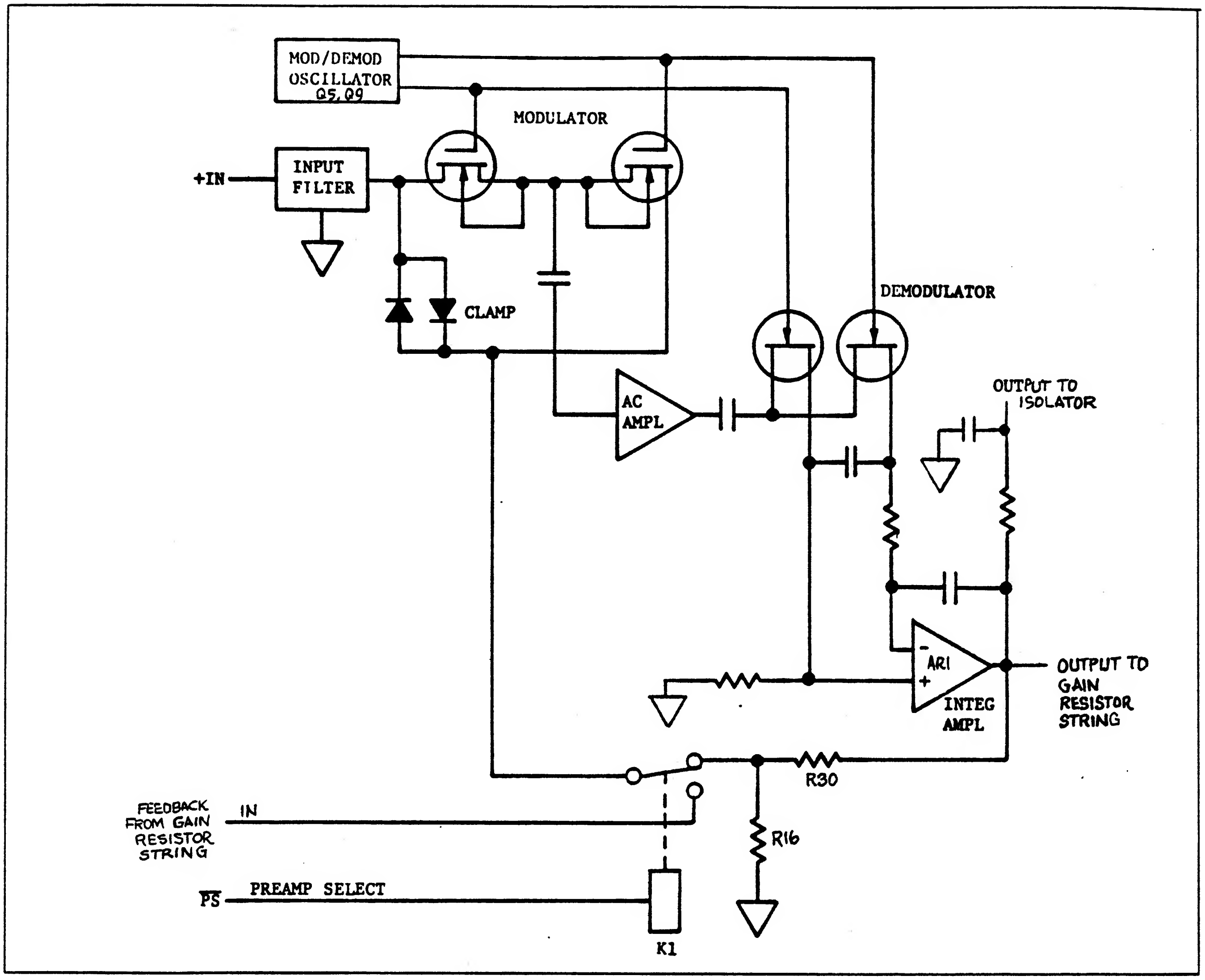


Figure 5.19 - Preamplifier

the Attenuator/Reference Board) and K1-D to the modulator.

5.3.5.7.3 The modulator produces a square wave difference signal which is amplified by the AC amplifier (Q6 and Q7) and rectified by the demodulator (Q1). The DC output level of the demodulator is amplified by the integrating amplifier (AR1) and routed to the output. R16 and R30 close the feedback loop when K1-A and K1-D are de-energized (Preamplifier not selected).

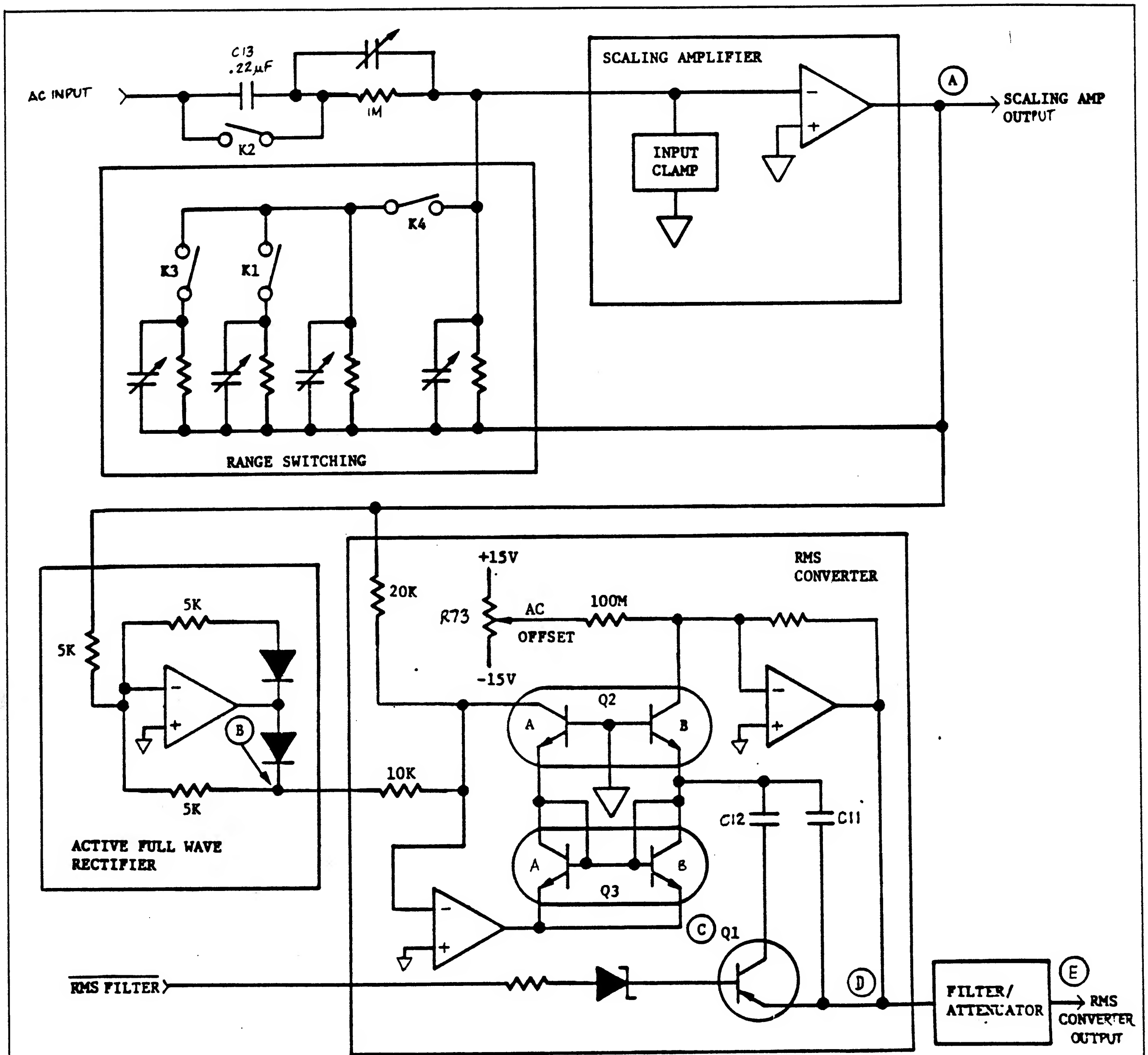
5.3.5.8 TRUE RMS CONVERTER BOARD (OPTION 10).

5.3.5.8.1 The True RMS Converter (Figure 5.20) is comprised of a range switching network, scaling amplifier, active rectifier, RMS converter and attenuator/filter network.

5.3.5.8.2 *Range Switching.* The input signal is routed through C13 (AC coupled AC) or through K2 (DC coupled AC) to the range switching network. The range switching circuitry provides signal attenuation in the 10 volt, 100 volt and 1000 volt ranges. The table in Figure 5.20 details the relay closures for each range.

5.3.5.8.3 *Scaling Amplifier.* The scaling amplifier (Q5 and AR2) is an inverting operational amplifier which takes the input signal and provides a full scale output of 1.4 volts AC peak in all ranges. The feedback path for the amplifier is through the frequency compensated range switching circuitry. Q11-Q14 are clamps to protect Q5 from input overload voltages.

5.3.5.8.4 *Active Rectifier.* The active rectifier circuitry (Q4, Q6 through Q10, CR2 and CR3) is configured as an



RANGE	RELAY			
	K3	K1	K4	K2
1				*
10			X	*
100		X	X	*
1000	X		X	*

X = ENERGIZED

* NOTE: K2 IS ENERGIZED WHEN DC COUPLED AC IS SELECTED

FULL SCALE OUTPUTS

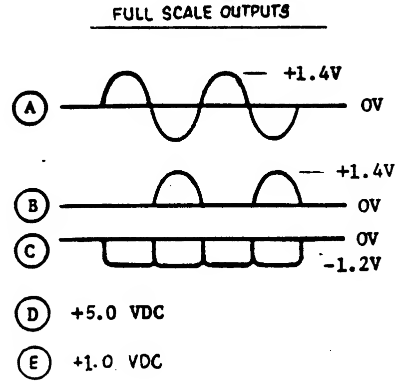


Figure 5.20 - True RMS Converter

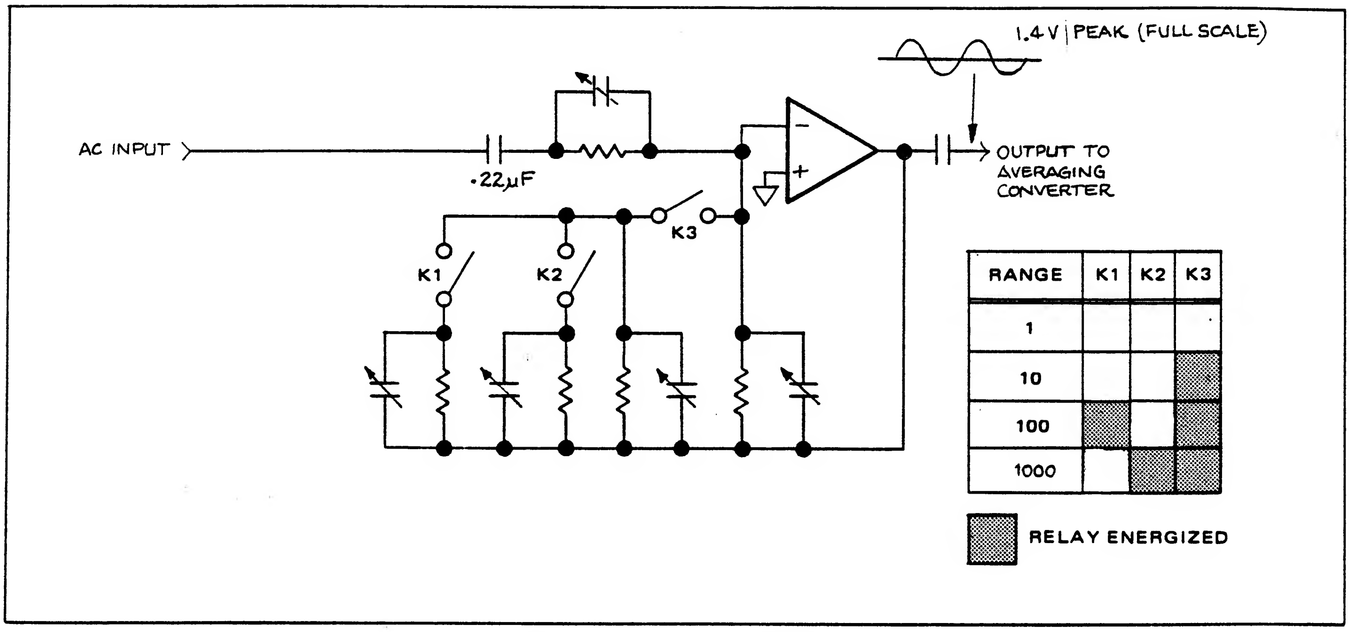


Figure 5.21 - Scaling Amplifier

operational amplifier with two polarity selective feedback paths. One feedback path (through CR3) conducts only with a negative amplifier output. The voltage developed across the positive conducting leg is applied to the input of the RMS converter circuitry.

5.3.5.8.5 *RMS Converter.* The input stage of the RMS converter circuitry (Q2, Q3 and Q15 through Q17) is configured as an operational amplifier with a logarithmic feedback loop. The output of the active rectifier and the output of the scaling amplifier are summed at the input of the log amplifier. The output of the log amplifier is the log of the total input and is routed through Q3B and Q2B to the input of AR1.

5.3.5.8.6 AR1 acts as a summing amplifier and converts the signal to a DC level. The ripple content of the output is filtered and attenuated to provide a scaled DC equivalent of the true RMS value of the original input signal. Q1 connects C12 in parallel with C11 to provide additional filtering when the FILTER key is toggled on.

5.3.5.9 AVERAGING AC CONVERTER BOARDS (OPTION 14).

5.3.5.9.1 The Averaging AC Converter is comprised of two circuit boards: a Scaling Amplifier Board and an Averaging Converter Board.

5.3.5.9.2 *Scaling Amplifier.* The Scaling Amplifier (Figure 5.21) is configured as an AC coupled inverting operational amplifier. The input signal is routed through C17 to the range switching network. The range switching circuitry provides signal attenuation in the 10 volt, 100 volt and 1000 volt ranges. The table in Figure 5.21 details the relay closures for each range.

5.3.5.9.3 The scaling circuitry (Q1 through Q10) takes the input signal and provides a full scale output of 1.4 volts AC peak in all ranges. The feedback path for the amplifier is through the frequency compensated range switching circuitry.

5.3.5.9.4 *Averaging Converter.* The Averaging Converter (Figure 5.22) receives the scaled AC signal from the Scaling Amplifier and applies it to the active rectifier stage. The active rectifier circuitry (Q1 through Q6, Q9 through Q11, AR3, CR2 and CR3) is configured as an operational amplifier with two polarity selective feedback paths. One feedback path (through CR3) conducts only with a negative amplifier output and the other path (through CR2) conducts only with a positive amplifier output. The voltage developed across the negative conducting leg is applied to the input of the summing amplifier circuitry.

5.3.5.9.5 The output of the active rectifier is summed with the output of the Scaling Amplifier at the inverting

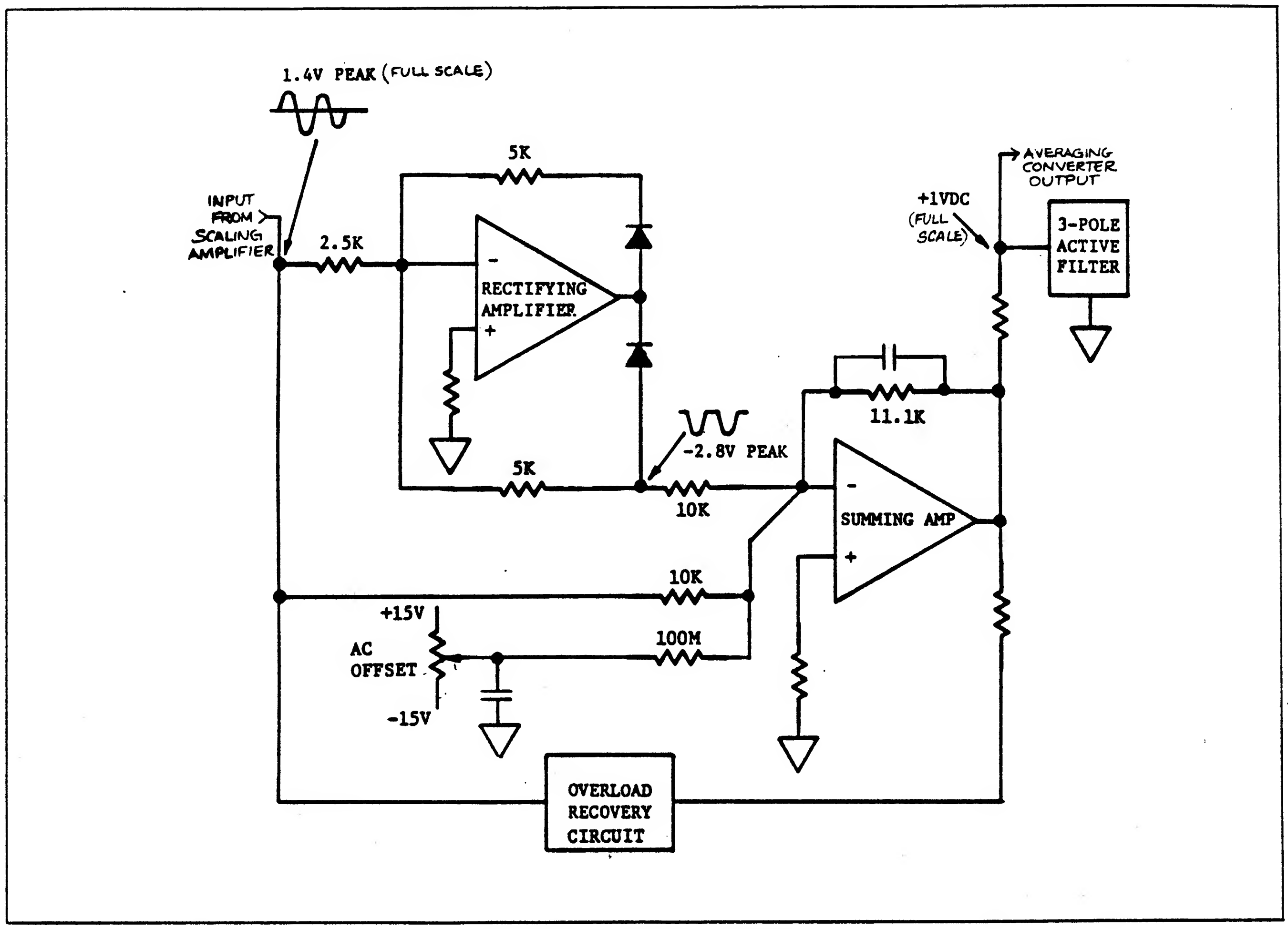


Figure 5.22 - Averaging Converter

input of the summing amplifier (Q8 and AR2). The output of the summing amplifier is 1.11 times the average of the summed inputs. Ripple attenuation is provided by the summing amplifier and the 3-pole active filter (AR1). The AC Averaging Converter output is a scaled DC equivalent of the average value of the original input signal. Fast recovery from overload conditions is provided by Q13 and Q14.

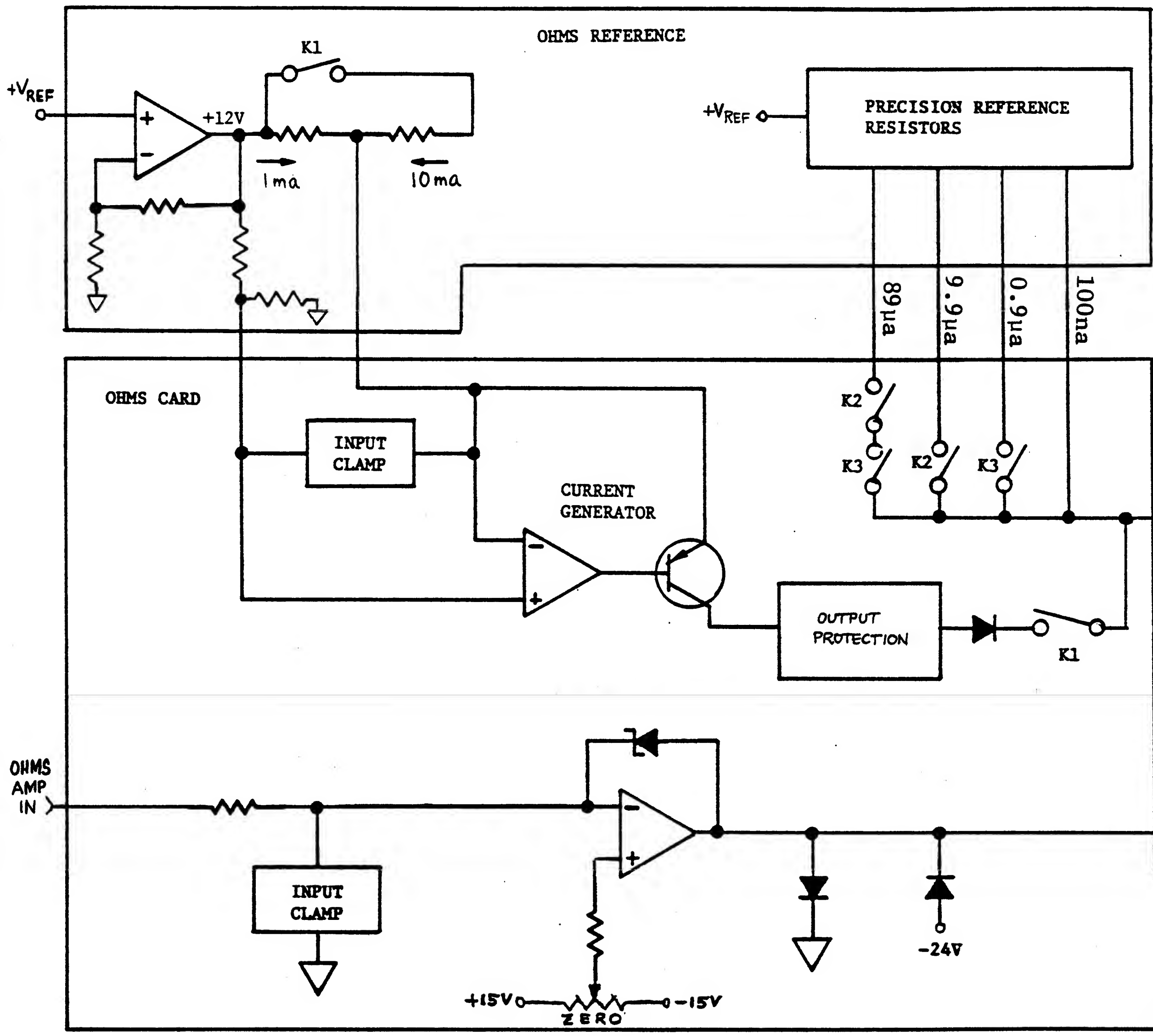
5.3.5.10 OHMS CONVERTER BOARDS (OPTION 24).

5.3.5.10.1 The Ohms Converter (Figure 5.23) is comprised of two circuit boards: Ohms Reference and Ohms Card.

5.3.5.10.2 *Ohms Reference.* The Ohms Reference is comprised of operational amplifier AR1 and a set of precision resistors. The Ohms Reference supplies precision current outputs to the Ohms Card. When K1 is energized, the 1 ma current source becomes a 10 ma current source. The table in Figure 5.23 details the relay closures for each range.

5.3.5.10.3 *Ohms Card.* The Ohms Card routes the appropriate current to the resistance under test and amplifies the returned signal. The current generator (Q1 through Q7 and AR1) supplies the 1 ma or 10 ma output current through K1 on the Ohms Card. The 89.1 μa, 9.9 μa, 900 na and 100 na currents from the Ohms Reference are routed through K2 and K3 and added together to produce 100 na, 1 μa, 10 μa and 100 μa currents. The table in Figure 5.23 details the relay closures for each range. The circuitry formed by Q8 through Q11 and Q15 through Q17 provides overvoltage protection for the current generator.

5.3.5.10.4 The signal returned by the resistance under test is routed to an amplifier circuit consisting of input buffer Q14, gain amplifier AR2 and power amplifier Q20.



RANGE	OHMS CONVERTER			OHMS REFERENCE
	K1	K2	K3	K1
1Ω	■			■
10Ω	■			■
100Ω	■			■
1KΩ	■			
10KΩ	■			
100KΩ		■	■	
1MΩ		■		
10MΩ			■	
100MΩ				

■ ENERGIZED

Figure 5.23 - Ohms Converter

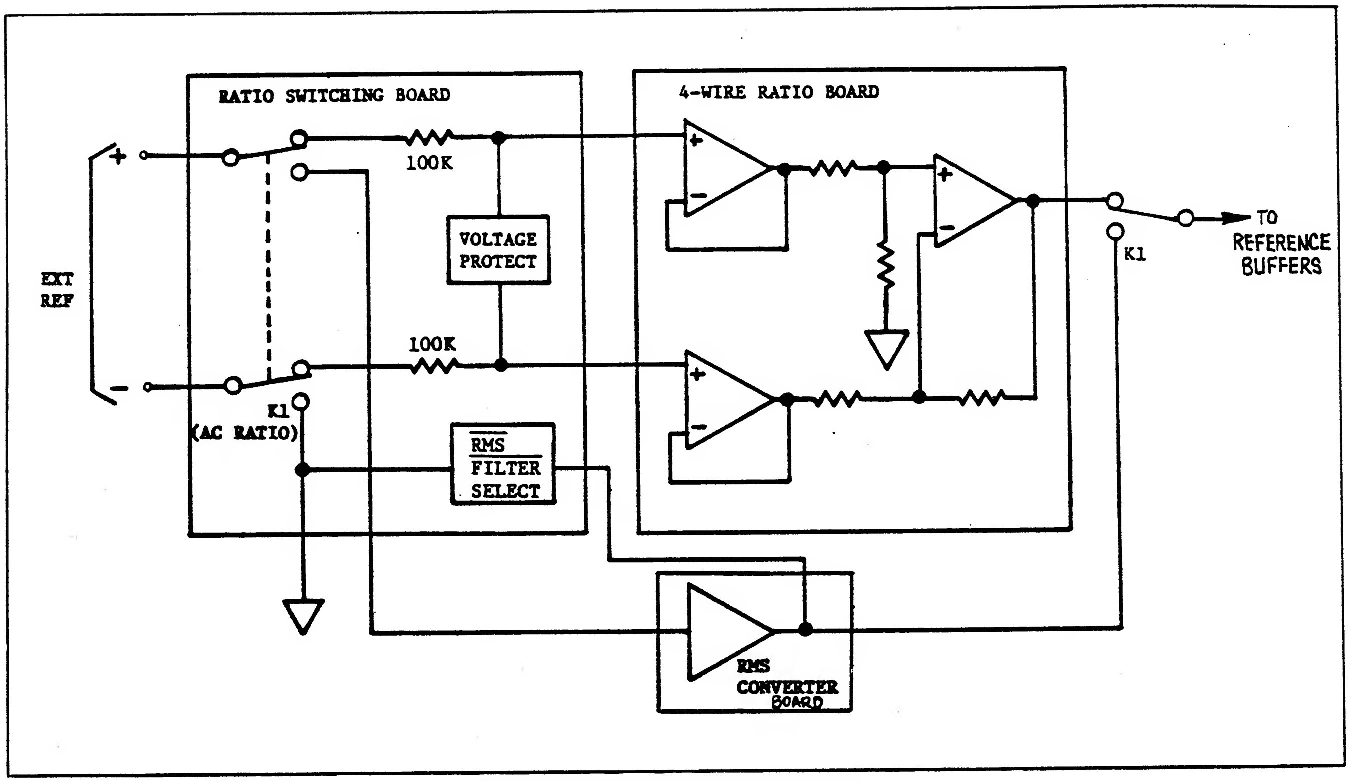


Figure 5.24 - AC/DC Hardware Ratio

5.3.5.11 HARDWARE RATIO BOARDS.

5.3.5.11.1 The Hardware Ratio circuitry (Figure 5.24) consists of the Ratio Switching Board, 4-Wire Ratio Board (Option 34) and RMS Converter Board (Option 11).

5.3.5.11.2 *4-Wire Ratio.* DC external voltages between +1.0 volt and +10.5 volts may be used as the reference for 4-Wire Ratio measurements when DC EXT REF is selected. The differential inputs of the reference are applied to the non-inverting inputs of separate operational amplifiers (AR1 and AR2). The outputs of AR1 and AR2 are applied to the differential inputs of operational amplifier AR3. The 4-Wire Ratio circuitry produces a single-ended output from differential inputs, thus allowing the input reference voltage to float with respect to input signal common.

5.3.5.11.3 *RMS Converter.* External reference voltages from 0.1 to 1000 volts AC or DC can be used when AC EXT REF is selected. In this mode the reference voltage is routed to the RMS Converter. The RMS Converter is identical to the True RMS Converter Board described in paragraph 5.3.5.8.

5.4 DIGITAL CONTROL.

5.4.1 The following paragraphs present a detailed analysis of the Digital Control section. A block diagram may be found in Figure 5.25.

5.4.2 The Digital Control section of the Model 6000 contains the following boards:

- Computer (J3)
- Display/Keyboard
- Control Logic (J4)
- Calibration Memory
- Fast Waveform Digitizer (J5)

5.4.3 Circuit Descriptions.

5.4.3.1 The following paragraphs contain descriptions of the circuitry and block diagrams of the circuit boards in the Digital Control section. Detailed schematics may be found in Section 7.

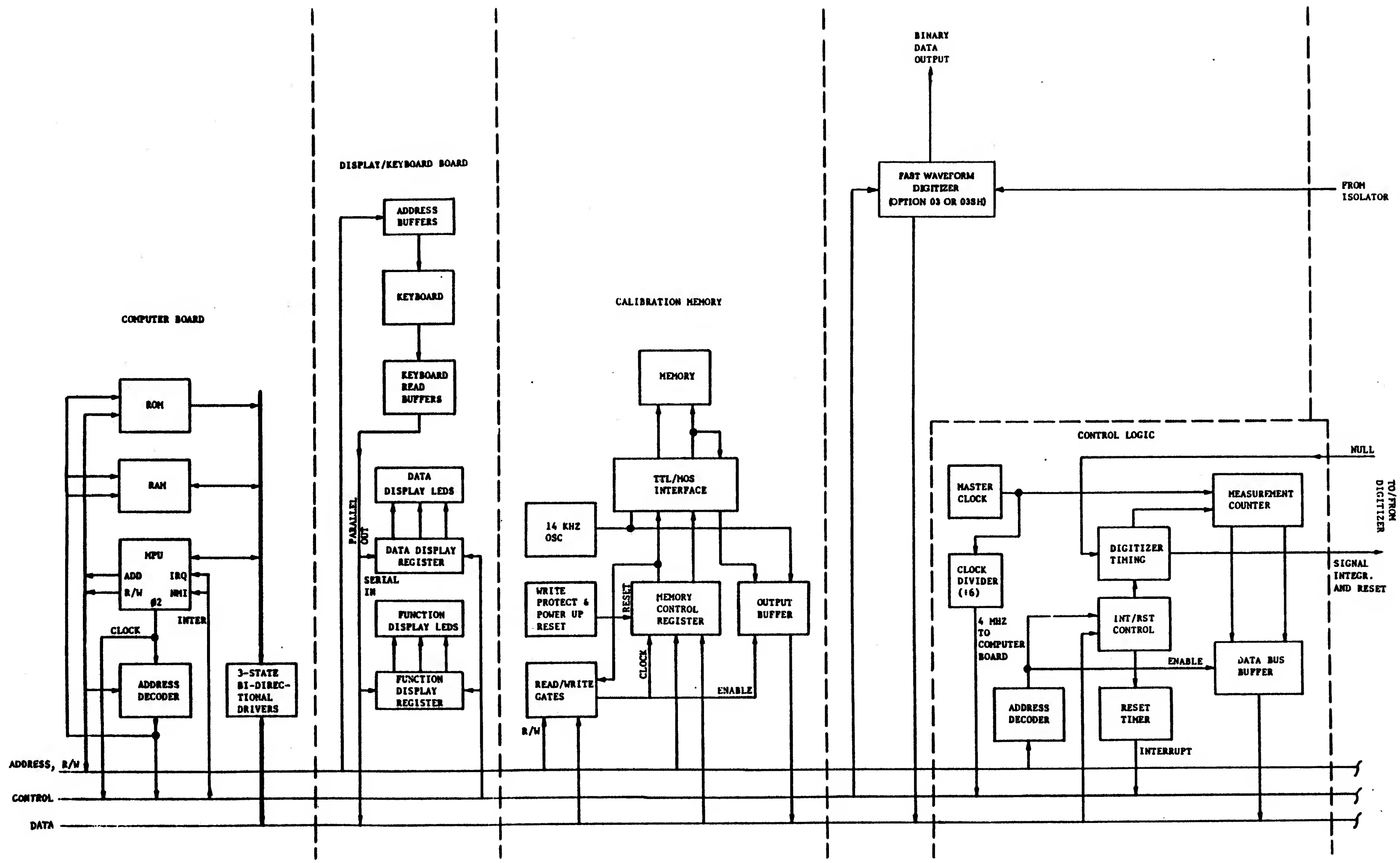


Figure 5.25 - Digital Section Block Diagram

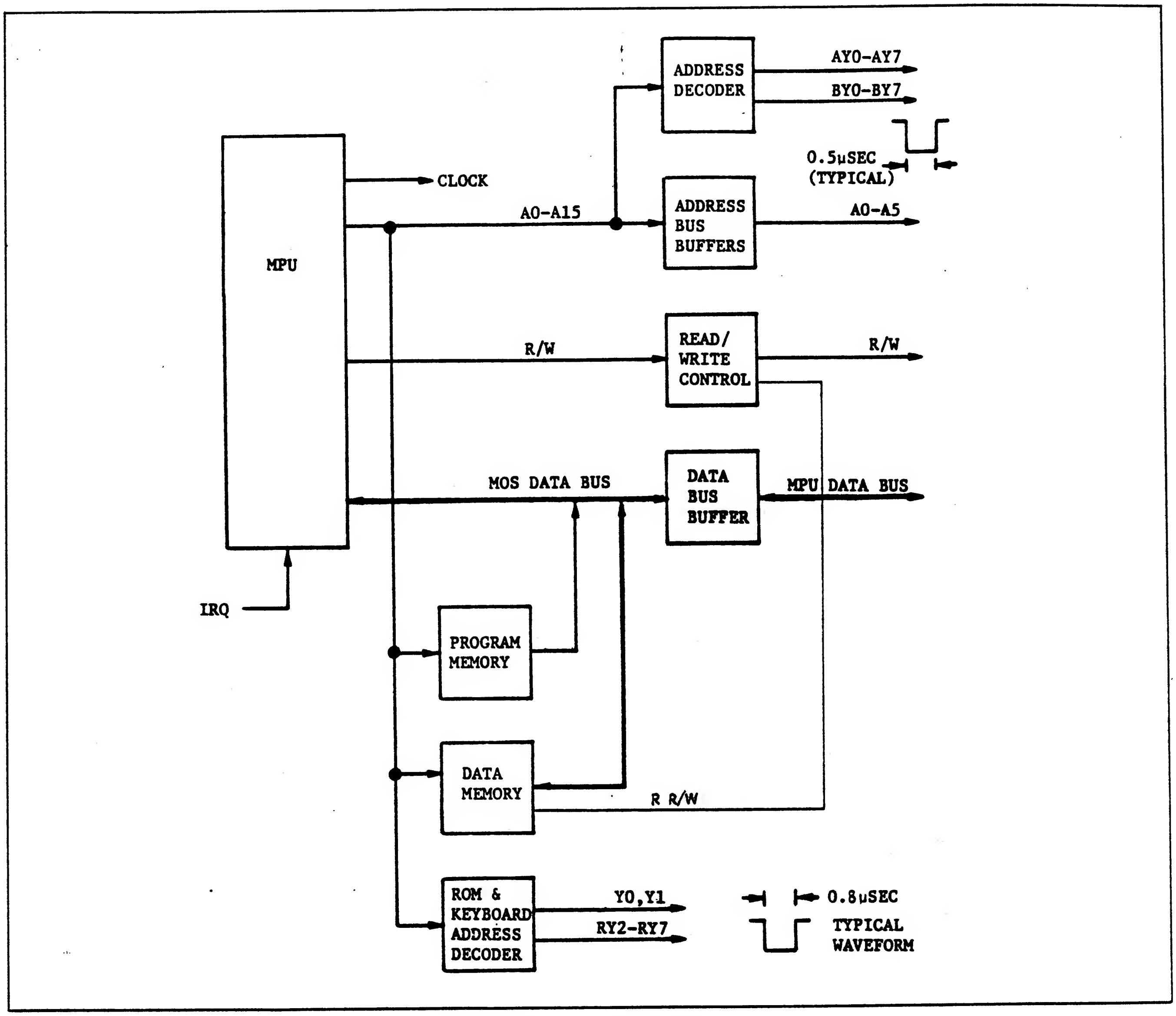


Figure 5.26 - Computer Board

5.4.3.2 COMPUTER BOARD.

5.4.3.2.1 The Computer Board (Figure 5.26) contains program storage and processing circuitry. The circuitry consists of a microprocessor, random access memory (RAM), read only memory (ROM), address decoders and read/write control logic.

5.4.3.2.2 *Microprocessor.* The microprocessor (U12) is an 8-bit unit with built in clock generator and 128x8 RAM. The microprocessor provides for processing of the digital data within the DMM. The data bus lines are routed through three-state buffers U5, U6 and U7. Address lines A0 thru A5 are routed through three-state buffer U8.

5.4.3.2.3 *Memory.* The memory circuitry consists of RAM and ROM. The RAM (U13 thru U16 and part of the microprocessor) provides a total of 640 bytes of temporary data storage area. The ROM (U17 thru U21 and U11) provides 10k bytes of primary program storage and 2k bytes of storage for the interface program.

5.4.3.2.4 *Address and Read/Write Logic.* The address decoding circuitry (U3, U9 and U10) decodes the address lines into separate enable lines for the circuits which are connected in common to the data bus. The read/write control logic (U1, U2, U4 and U6) provides the proper read and write timing during data processing.

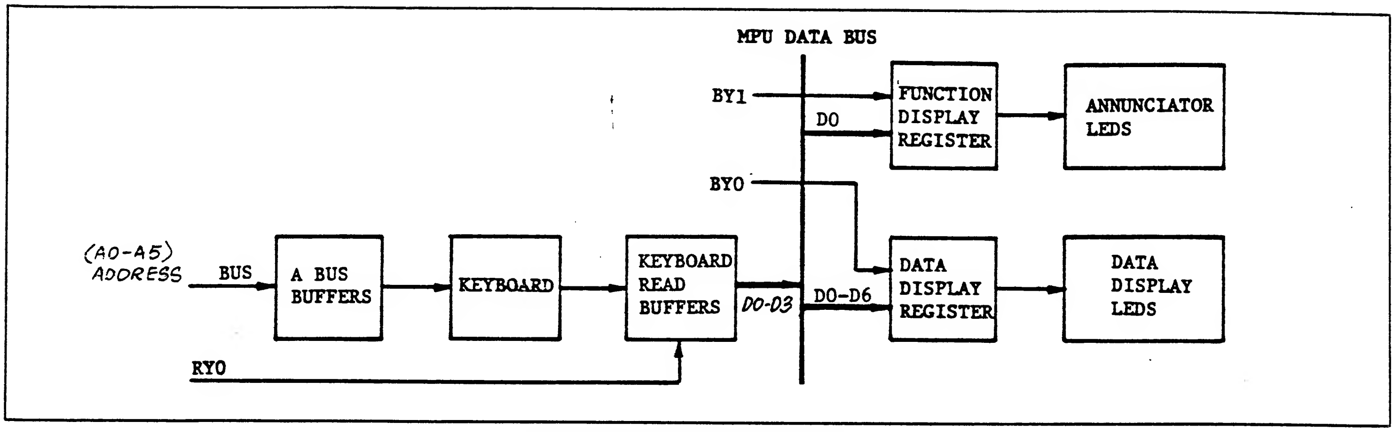


Figure 5.27 - Display/Keyboard

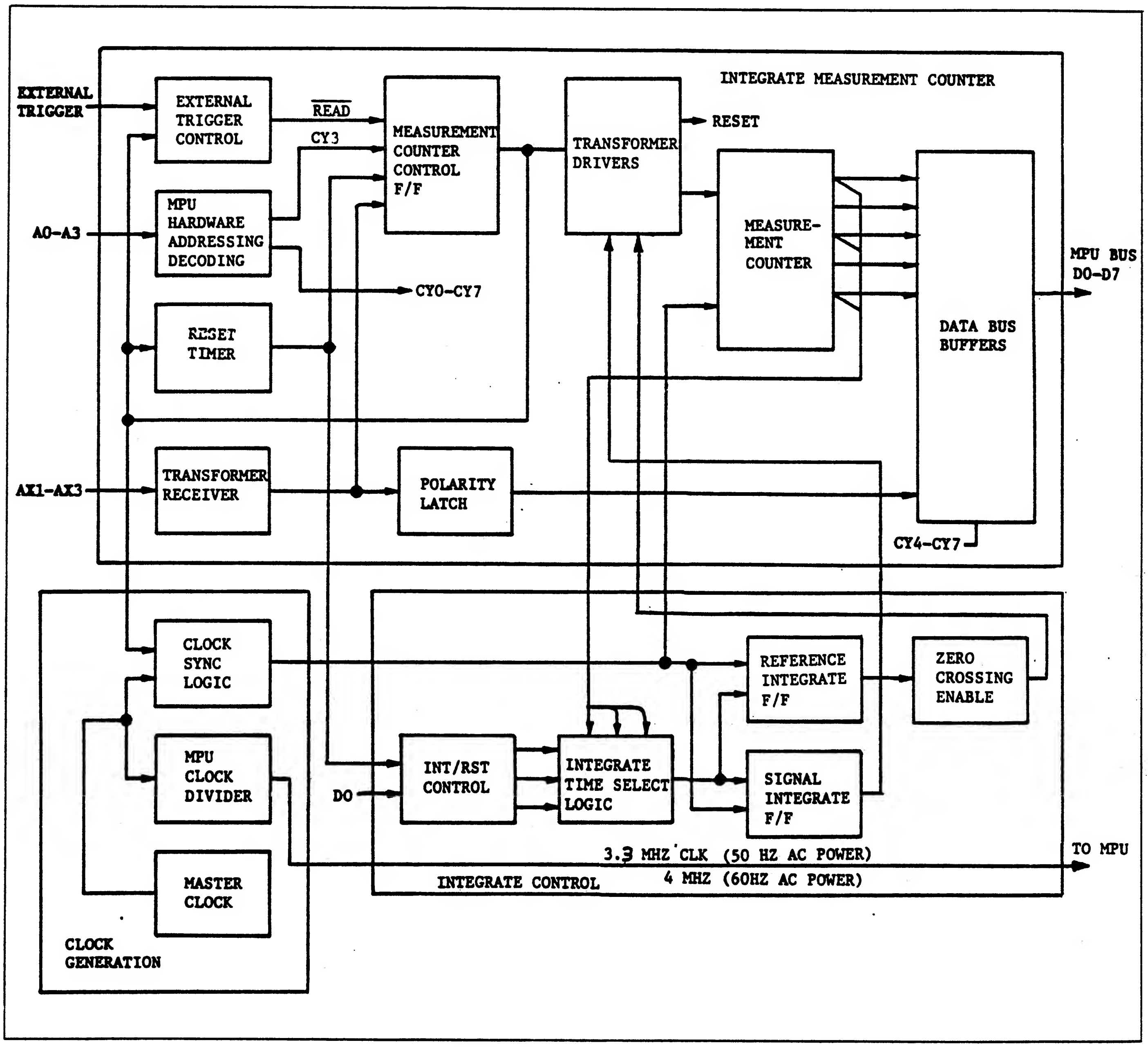


Figure 5.28 - Control Logic

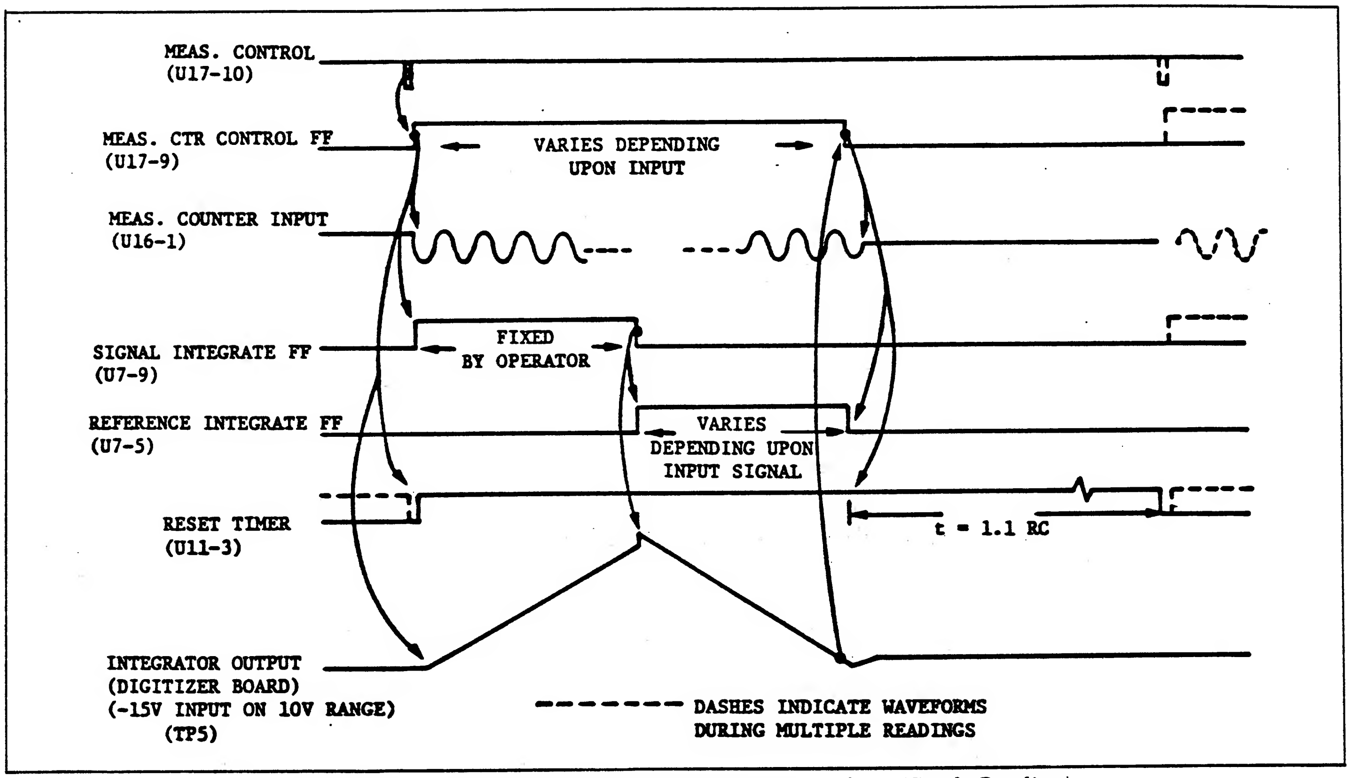


Figure 5.29 - Control Logic Digitizer Schematic Waveform (Single Reading)

5.4.3.3.1 DISPLAY/KEYBOARD.

5.4.3.3.1 The Display/Keyboard (Figure 5.27) provides for input of function and range information and for the display of data and operational statuses.

5.4.3.3.2 *Keyboard.* The Keyboard circuitry (U11 and U12) provides for the input of addresses from the Computer Board and the output of data from the Keyboard matrix. When the microprocessor addresses the Keyboard (RYO low), it also places ones on address lines A0 thru A5. If a key is pressed, the microprocessor will manipulate the pattern on address lines A0 thru A5 until the position of the pressed key is determined.

5.4.3.3.3 *Display.* The Display circuitry (U1 thru U10, LED 1 thru LED 9 and CR1 thru CR27) provides a display for data readout and annunciators for status indication. The function display registers (U8, U9 and U10) receive a 24-bit serial input which determines the status of the annunciators. The function data are received on data line D0 and are clocked into the registers by BY1 from the microprocessor address decoders.

5.4.3.3.4 The data display registers (U1 thru U7) receive a similar string of data from the microprocessor. The display data are received on data lines D0 thru D6 and are clocked into the registers by BY0 from the microprocessor address decoders. The outputs from the data display registers enable the segments of the display LEDs.

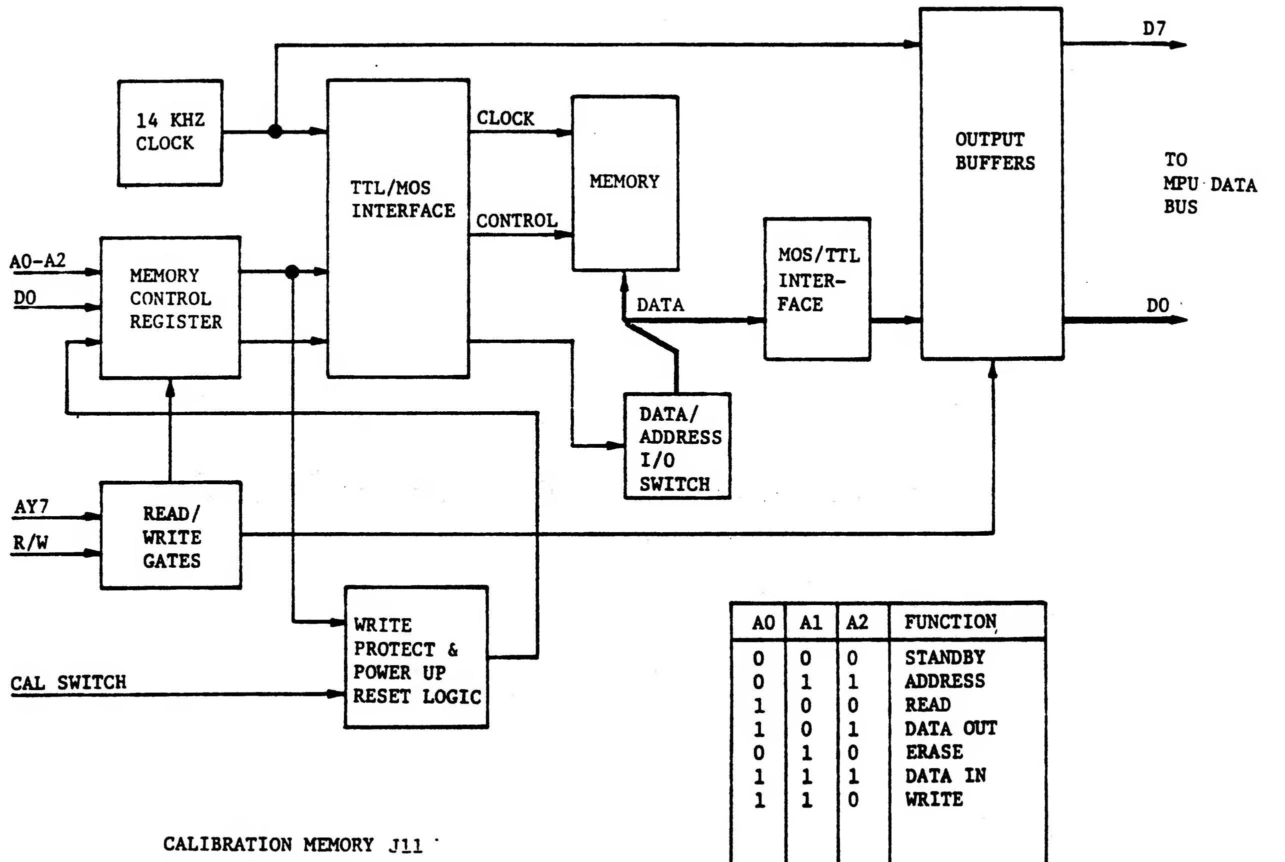
5.4.3.4 CONTROL LOGIC BOARD.

5.4.3.4.1 The Control Logic Board (Figure 5.28) provides the timing circuitry, integration control logic and measurement counters for the DMM.

5.4.3.4.2 *Timing Circuitry.* The timing circuitry contains a master clock (Q6, Q9 and Y1) that operates at 24 MHz in 60 Hz AC machines and at 20 MHz in 50 Hz AC machines. The output of the master clock circuit is routed to the clock sync flip-flop (U17) and to the clock divider circuit (U20 and U21). The clock divider circuit outputs a 4 MHz clock (60 Hz machines) or a 3.3 MHz clock (50 Hz machines for use by the microprocessor.

5.4.3.4.3 *Integration Control Logic.* The integration measurement counters (U12 thru U16) are enabled when a microprocessor trigger (CY3 output of the address decoder) or an external trigger initiates a measurement cycle. The trigger causes the measurement counter control flip-flop (U17) to set. This, in turn, causes the clock sync logic flip-flop (U17) to set, thus allowing a synchronized clock signal to clock the measurement counter. The signal integrate flip-flop (U7) is also set, and the output is applied to the signal integrate transformer driver (Q1, Q2). Figure 5.29 shows the Control Logic and Digitizer waveform relationships.

5.4.3.4.4 The signal integrate flip-flop (U7) is reset when the measurement count reaches a level that corresponds to



A0	A1	A2	FUNCTION
0	0	0	STANDBY
0	1	1	ADDRESS
1	0	0	READ
1	0	1	DATA OUT
0	1	0	ERASE
1	1	1	DATA IN
1	1	0	WRITE

Figure 5.30 - Calibration Memory

the selected integration period. The three upper decades of the counter (U12 thru U14) are also reset, and the reference integrate flip-flop (U7) is set. The Q output of the reference integrate flip-flop enables one input of the NAND gate (U6) in the zero-crossing enable circuit (U6 and U19). When a zero-crossing signal is received on transformer lines AX1 and AX3, the measurement counter control flip-flop (U17) is reset, the clock sync logic flip-flop is disabled and the input to the measurement counter is stopped.

5.4.3.4.5 At the end of the measurement sequence, the information stored in the measurement counter and the polarity latch (U19) is requested by the microprocessor. The three-state data bus buffers (U1 thru U5) are sequentially enabled to place the data on the data bus.

5.4.3.5 CALIBRATION MEMORY BOARD.

5.4.3.5.1 The Calibration Memory (Figure 5.30) provides storage for the calibration offset factors. The circuitry consists of an electrically alterable read only memory, a clock generator and associated logic.

5.4.3.5.2 *Memory.* The memory (U4) transmits and receives data and address information on a single data line. Information on the data line is in serial form and is clocked in or out of the memory by the 14 KHz clock signal provided by U6. The three control lines for the memory are latched into U1. The table in Figure 5.30 lists the various combinations of control line addresses and the resultant functions.

5.4.3.5.3 The logic formed by U2 and U3 resets the memory control register to the "standby" address during power up. The "standby" address is also entered if the microprocessor sends a "write" address when the LAB CAL switch is off. Data/address switch Q6 is enabled whenever the microprocessor sends data or address information to the memory and transistors Q1-Q5, Q7 and Q8 act as TTL to MOS and MOS to TTL logic translators.

5.4.3.6 FAST WAVEFORM DIGITIZER BOARD (OPTION 03).

5.4.3.6.1 The Fast Waveform Digitizer (Figure 5.31) provides for high speed digitizing of analog signals. The circuitry

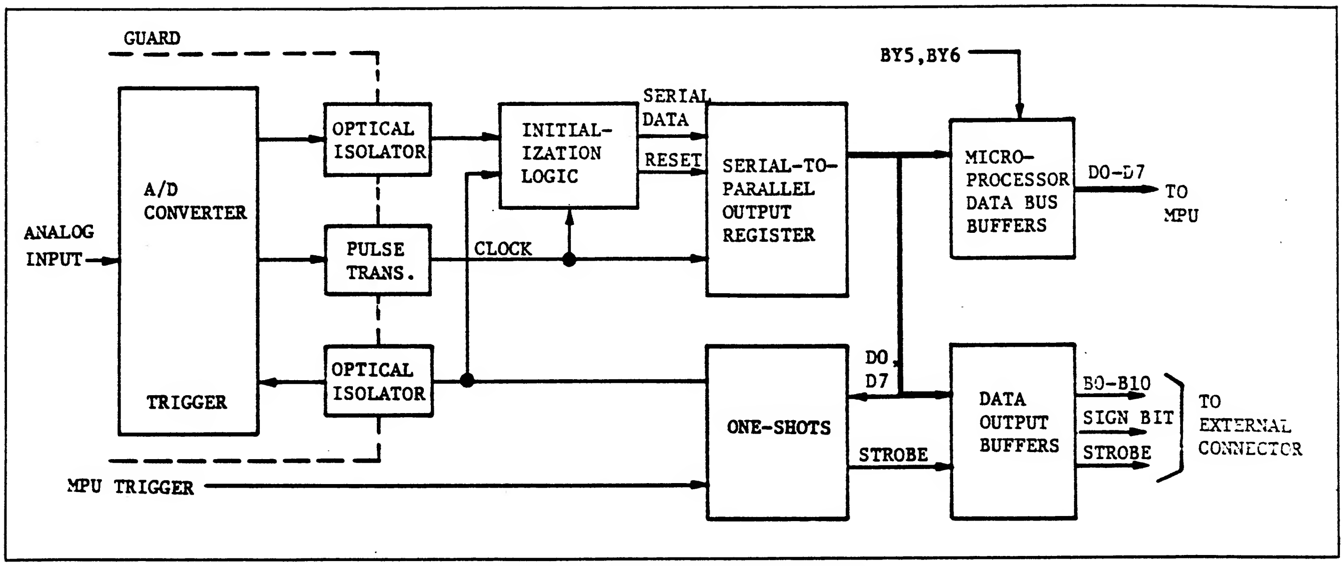


Figure 5.31 - Fast Waveform Digitizer

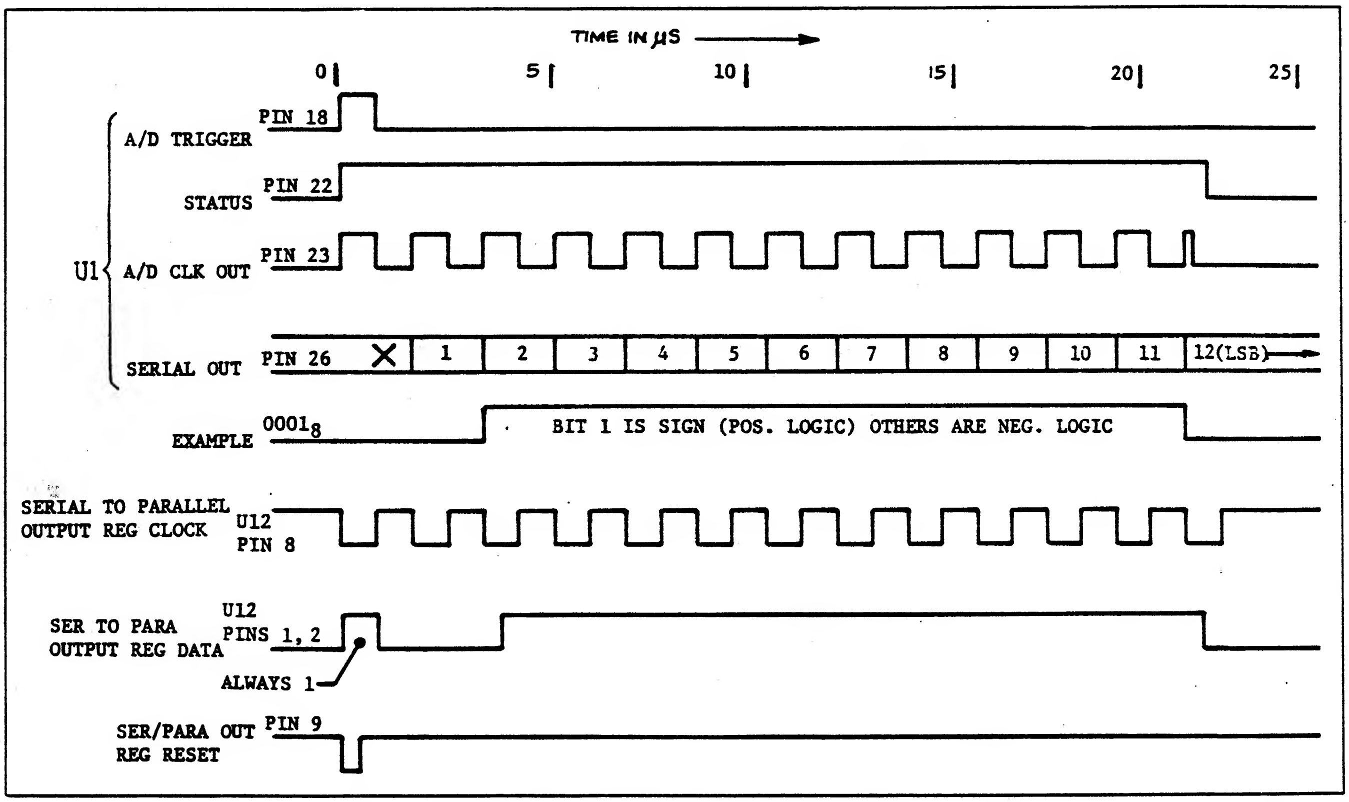


Figure 5.32 - Fast Waveform Digitizer Timing

consists of a 12-bit analog to digital (A/D) converter, initialization logic, serial to parallel output register and data buffers.

5.4.3.6.2 *A/D Converter.* The A/D converter (U1) is connected so that the output ranges between +2047 and −2047 counts. The analog input is scaled as follows for the different ranges: .1 mV/count (100 mV range), 1 mV/count (1 volt range), 10 mV/count (10 volt range), 100 mV/count (100 volt range) and 1V/count (1000 volt range). The digital output is derived from the serial binary output of U1.

5.4.3.6.3 A negative going trigger from either the microprocessor or from an external source starts the conversion sequence by causing pin 8 of U8 to go high. U8, in turn, triggers one shot U7. The Q output of U7 is coupled through U3 and causes one shot U2 to trigger. The Q output of U2 triggers the A/D converter.

5.4.3.6.4 The clock output of the A/D converter is squared (by the second one shot in U2), routed across guard through pulse transformer T1 and applied to the initialization logic at one input of NAND gate U8. The other

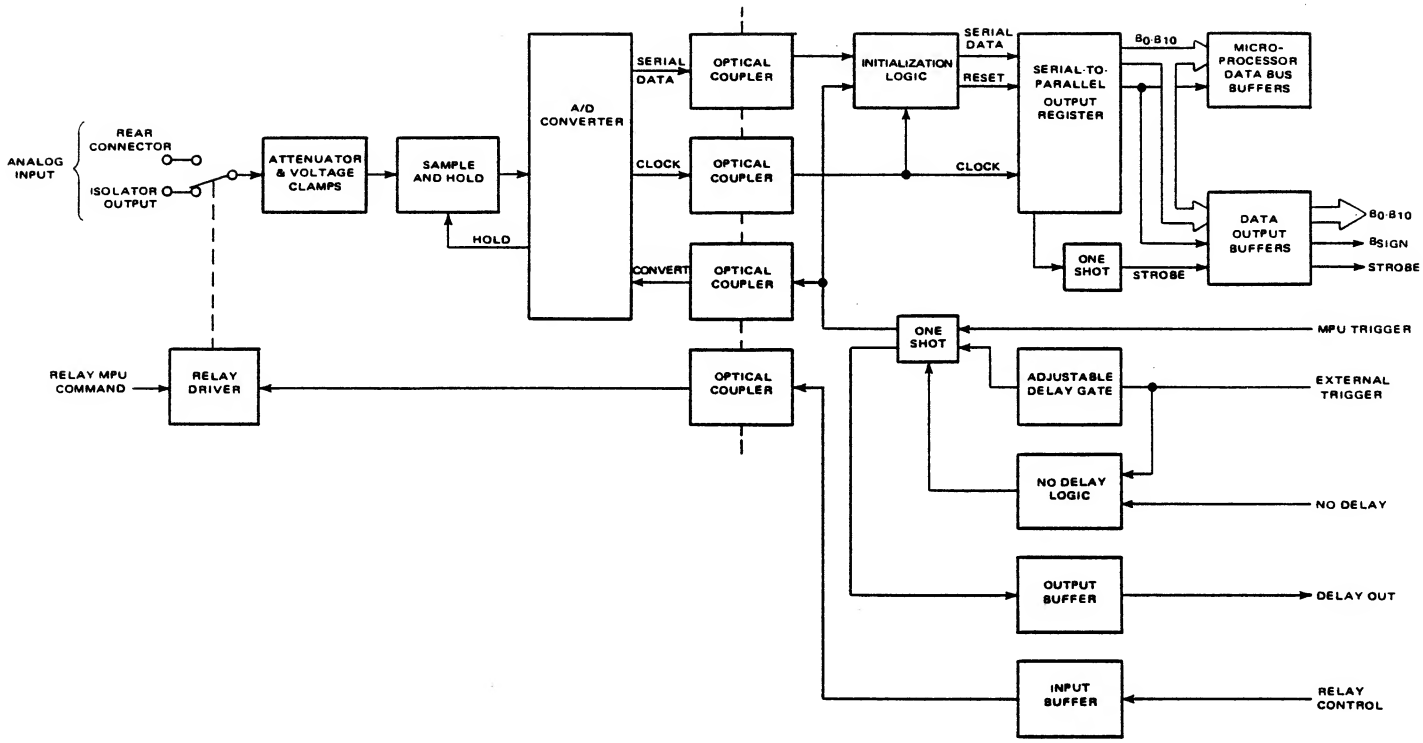


Figure 5.33 - Sample and Hold Fast Waveform Digitizer

input to U8 is the squared equivalent of the trigger pulse (taken from the Q output of U7). The low going output of U8 resets serial to parallel output registers U12 and U14. After the register is reset, a true signal bit is clocked into the serial input of U14, followed by 12 data bits from the A/D converter. When the signal bit reaches position 13 of the registers (U12 pin 10), one shot U7 is triggered and the 12 data bits are strobed through the output buffers. The data bits are also presented to the microprocessor data bus (in two bytes) when BY5 and BY6 are enabled. Digitizer timing is shown in Figure 5.32.

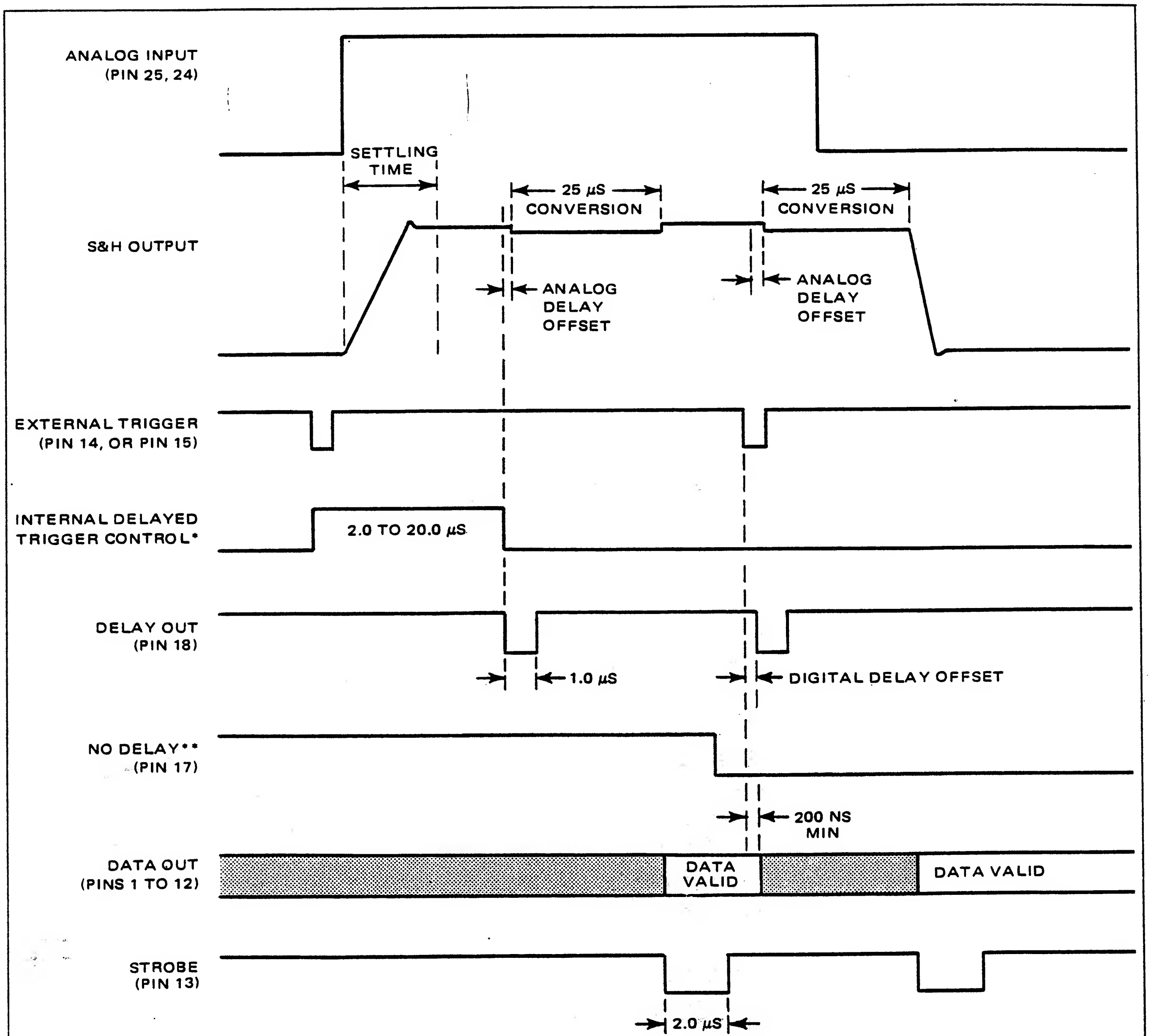
5.4.3.7 FAST WAVEFORM DIGITIZER SAMPLE AND HOLD BOARD (OPTION 03 SH).

5.4.3.7.1 The Sample and Hold (S/H) Digitizer (Figure 5.33) provides for high speed digitizing of analog signals. The S/H circuitry increases the data bandwidth of the Digitizer, and allows for the digitizing of selected portions of input waveforms. The circuitry consists of a Fast A/D Input Select relay, input attenuator, sample and hold section, 12-bit analog to digital (A/D) converter, initialization logic, serial to parallel output register, data buffers, trigger delay gates and relay control circuitry.

5.4.3.7.2 The Fast A/D Input Select relay is a DPDT switch that can be set to select either the voltage from the Isolator output or the voltage applied between pins 24 and 25 of the Fast A/D connector (on the rear panel). The relay can be controlled by a GPIB command or by applying a TTL signal to pin 19 of the Fast A/D connector (TTL low will energize).

5.4.3.7.3 *S/H Circuitry*. The S/H circuitry consists of an input buffer, a JFET switch, a holding capacitor and an output buffer. The selected input signal is routed through the input buffer (AR1) and the JFET switch (Q7) to the holding capacitor (C22). The holding capacitor will track the input voltage until a Convert command is received from the microprocessor or from pin 14 or 15 of the Fast A/D connector. The Convert command is coupled through opto-isolator OCI-2 to pin 18 of A/D converter U1. U1 then sends out a Hold command on pin 22 which opens the JFET switch. With the JFET switch open, the voltage to the A/D converter (from output buffer AR2) will remain at the level stored in C22 until the conversion process is completed.

5.4.3.7.4 *Trigger Delay*. The trigger delay circuitry consists of a delay time one shot and the delay logic. The delay time one shot (1/2 U9) has a delay time output of 2μs to 20μs (adjusted by R33). If the NO DLY line on the Fast A/D connector is low, then the trigger applied at E6 (TC) or E16 (TD) will bypass the delay time one shot and trigger the 1μs one shot (1/2 U6) directly. If the No Delay line is at TTL high, then the delay time one shot will trigger for the set delay time before triggering U6. A microprocessor Convert command is not affected by the delay time one shot since it triggers U6 directly.



*THE INTERNAL DELAYED TRIGGER CONTROL IS LOCATED ON THE DIGITAL SIDE OF THE S&H BOARD AND IS A 100 KΩ POTENTIOMETER. TURNING THE POT CLOCKWISE REDUCES THE DELAYED TRIGGER TO A MINIMUM OF 2.0 µS, AND COUNTERCLOCKWISE INCREASES THE DELAYED TRIGGER (OR HOLD COMMAND TO THE S&H JFET SWITCH) TO A MAXIMUM OF 20.0 µS.

**CONNECTING PIN 17 TO DIGITAL TTL LOW BYPASSES THE INTERNAL DELAYED TRIGGER CONTROL AND ALLOWS THE USER TO CONNECT HIS OWN DELAYED TRIGGER CONTROL.

Figure 5.34 - Sample and Hold Digitizer Timing

5.4.3.7.5 *A/D Converter.* The A/D converter (U1) is connected so that the output ranges between +2047 and −2047 counts. The analog input is scaled as follows for the different ranges: .1 mV/count (100 mV range), 1 mV/count (1 volt range), 10 mV/count (10 volt range and voltages applied to the rear input), 100 mV/count (100 volt range) and 1V/count (1000 volt range). The digital output is derived from the serial binary output of U1.

5.4.3.7.6 During the conversion process, the clock output of the A/D converter is routed across guard through opto-isolator OCI-3, squared by one shot U9 and then applied to the initialization logic at one input of NAND gate U7. The other input to U7 is the squared equivalent of the trigger pulse (taken from the Q output of U6). The low going output of U7 resets serial to parallel registers U11 and U13. After the register is reset, a true signal bit is clocked into the

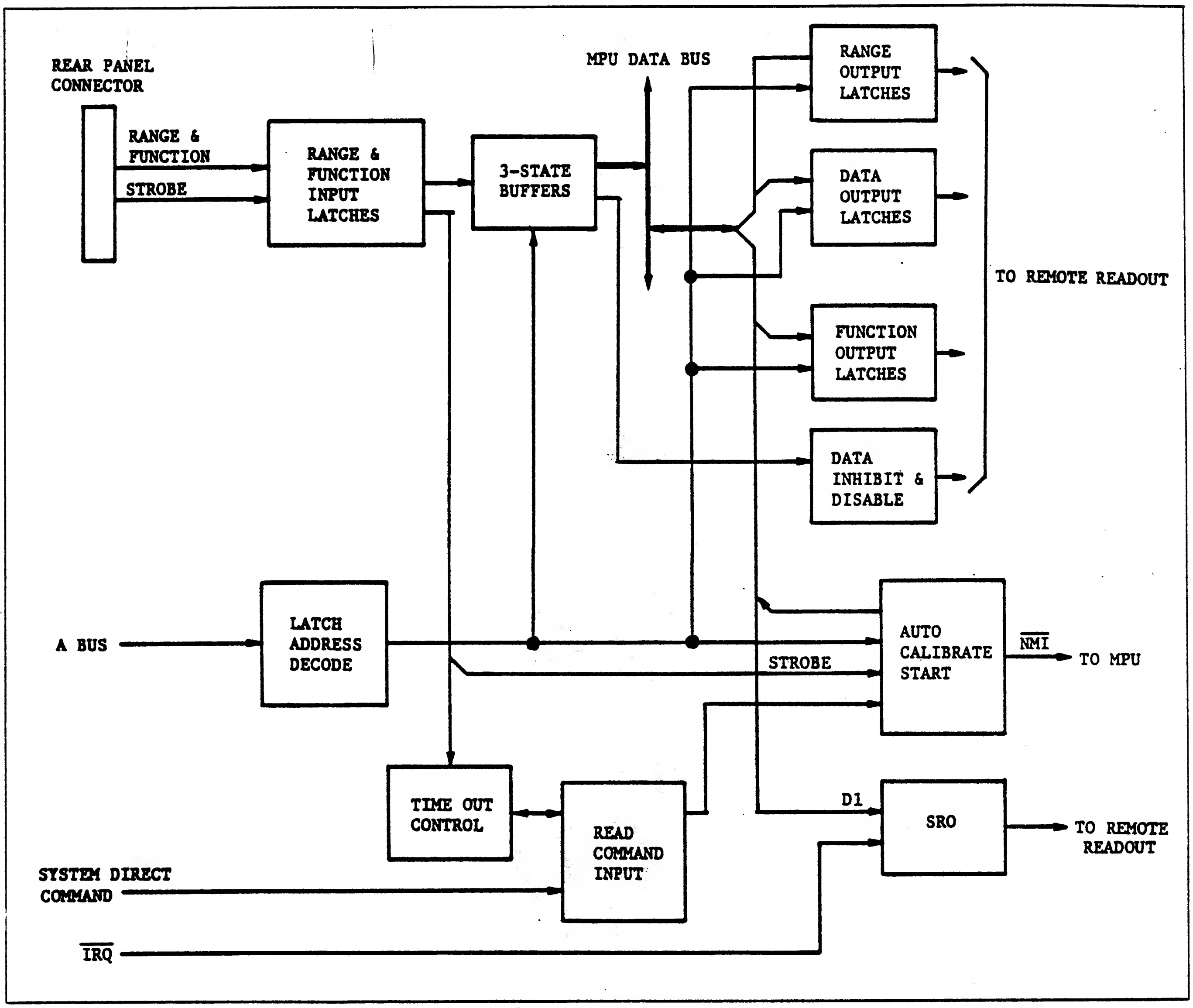


Figure 5.35 - Parallel BCD

serial input of U13, followed by 12 data bits from the A/D converter. When the signal bit reaches position 13 of the registers (U11, pin 10), a one shot (1/2 U6) is triggered and the 12 data bits are strobed through the output buffers. The data bits are also presented to the microprocessor data bus (in two bytes) when BY5 and BY6 are enabled. S/H Digitizer timing is shown in Figure 5.34.

5.5 SYSTEM INTERFACE.

5.5.1 Either of two types of interfaces may be used with the Model 6000. One is the Parallel BCD interface and the other is the General Purpose Interface Bus (GPIB). The GPIB conforms to IEEE Standard 488-1975.

5.5.2 Parallel BCD Interface.

5.5.2.1 The Parallel BCD interface (Figure 5.35) provides for remote programming of function and range. Upon completion of a measurement, the function, range and measurement data are routed through output ports to the remote device.

5.5.2.2 CIRCUIT DESCRIPTIONS.

5.5.2.2.1 The following paragraphs contain descriptions of the Parallel BCD interface circuitry. A detailed schematic may be found in Section 7.

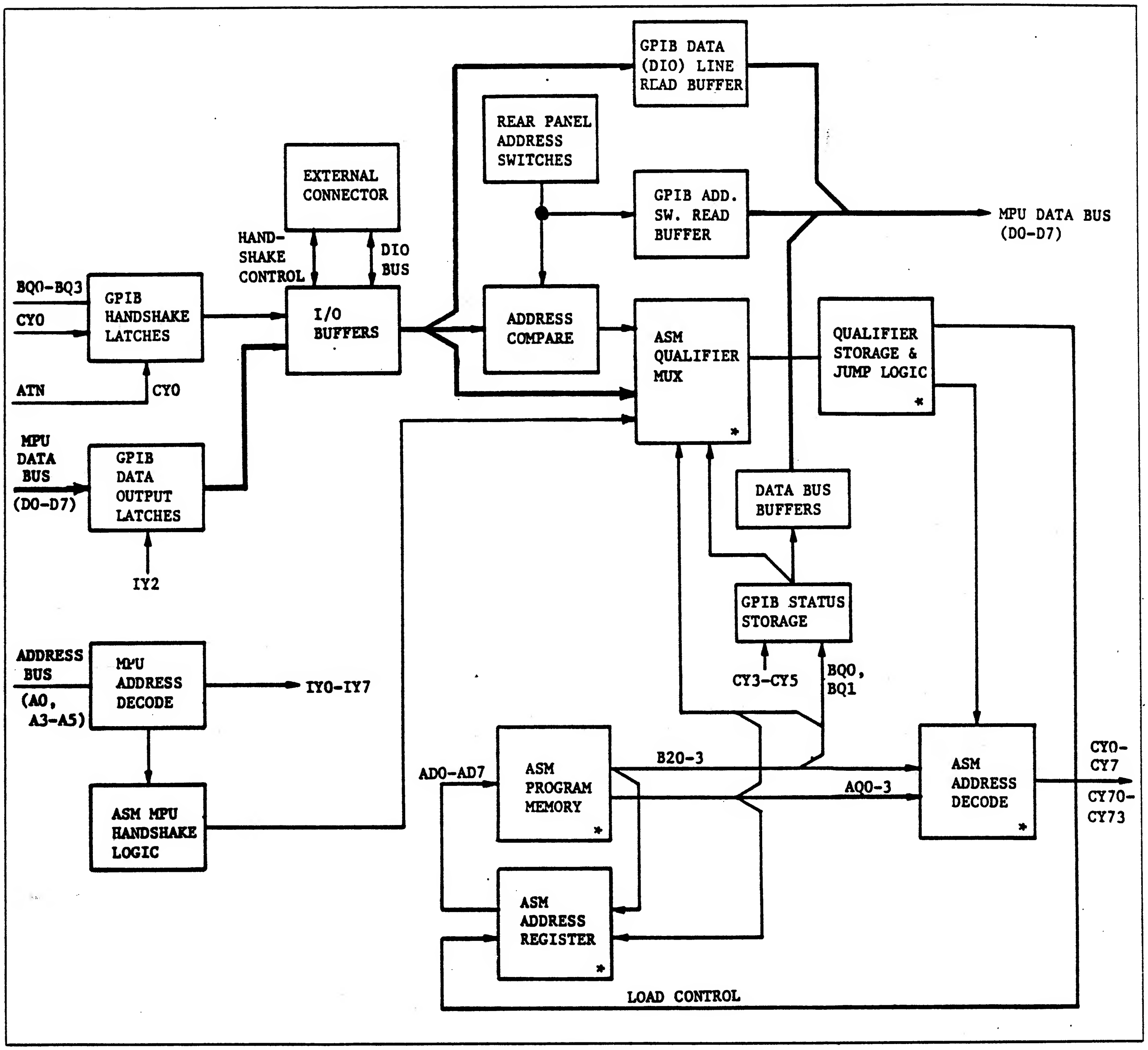


Figure 5.36 - GPIB IEEE-488 Interface Board

5.5.2.2.2 The controller defines the function and range for a measurement, and places this information on the interface lines. After the data has settled on the lines, the controller sends a program strobe which causes the data to be latched into the interface input latches (U17 thru U19). The program strobe also clocks flip-flop U5 in the Auto-Cal start circuit. The NMI signals the microprocessor that data has been stored, and the microprocessor responds by enabling the three state data bus buffers (U14 and U15). After the microprocessor has set the proper range and function, the controller sends a Read command to the interface.

5.5.2.2.3 The particular command sent (Direct, System Direct or Time Out) depends on the requirements of the controller. The Direct command will cause the DMM to take a measurement each time a negative pulse is received by the read command input circuitry (U22, U6 and U8). The System Direct command will cause the DMM to take continuous measurements as long as the command line is held at logical zero. The Time Out command will cause the DMM to take a measurement (after a preset time delay) each time a negative pulse is sent by the controller. The time delay is determined by range and function inputs to the time out control circuitry (U23 and U25).

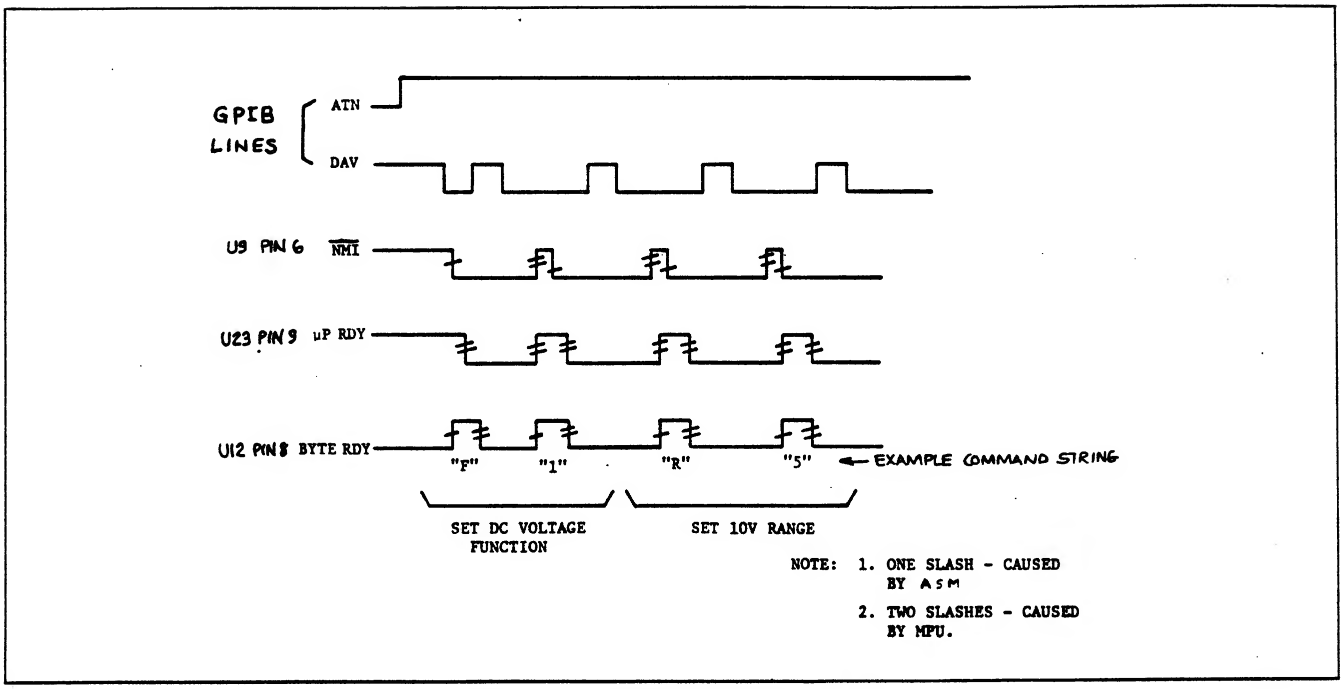


Figure 5.37 - GPIB Data Transfer to MPU

5.5.2.2.4 When a measurement has been completed, the microprocessor loads the range, function and data information into the output latches (U1 thru U3 and U10 thru U12). The latched information is available for local display and is also strobed into a remote readout device.

5.5.3 General Purpose Interface Bus.

5.5.3.1 The GPIB (Figure 5.36) allows the Model 6000 to operate on the IEEE 488 bus with controllers and other instruments. The interface is controlled by its own algorithmic state machine (ASM) which handles all interface commands and allows the GPIB to operate independent of microprocessor control.

5.5.3.2 CIRCUIT DESCRIPTIONS.

5.5.3.2.1 The following paragraphs contain descriptions of the GPIB circuitry. A detailed schematic may be found in Section 7.

5.5.3.2.2 The GPIB employs an 8-bit data bus and 8 lines for communications timing (handshaking) and control. Data is transmitted on the data lines as a series of 8-bit bytes. Data is transferred by means of a handshaking routine that permits asynchronous communication over a wide range of data rates. Bus communication is controlled by five lines that determine how information will be interpreted by devices on the bus. Three handshake lines control data byte transfer and permit synchronization of the transfer on the data bus.

5.5.3.2.3 *ASM.* The ASM is a 256 by 8 bit machine with a microcycle time of 250 nanoseconds. The circuitry consists of the ASM Qualifier Multiplexer, the Qualifier Storage and Jump Logic, the ASM Program Memory, the ASM Address Register and the ASM Address Decoder.

5.5.3.2.4 The ASM can perform two types of instructions: Store Output and Conditional Jump. The Store Output instruction requires one microcycle to complete and allows the ASM to latch the GPIB and ASM/MPU handshake control information. The Store Output instruction also allows the ASM to perform functions such as the setting/resetting GPIB status bits (eg: "Talker", "Listener" and "Remote") and the sending of interupts to the microprocessor via the NMI flip-flop. The Conditional Jump instruction requires two microcycles to complete. During the first microcycle qualifier select and control information, together with a bit indicating the beginning of a two cycle instruction, is made available on the ASM bus. At the end of the first cycle, the qualifier is latched in the Qualifier Storage and Jump Logic flip-flop (U10). During the second cycle, the jump address is placed at the parallel load inputs to the ASM Address Register (U15 and U16). The ASM Address Registers are parallel loadable binary counters which are either loaded or incremented by each clock pulse. The status

of the Qualifier Storage and Jump Logic determines whether or not the jump address is loaded on the succeeding clock pulse. If the jump address is not loaded, the ASM Address Registers will continue to increment as before.

5.5.3.2.5 The GPIB ATN (Attention) line determines how the messages on the Data I/O lines are interpreted. When ATN is low, the bytes sent over the bus are intended for the GPIB board. When ATN is high, the bytes are intended for the microprocessor. In order to receive bytes from the controller, the GPIB board must have been made a listener while ATN was low. The controller does this by sending the GPIB board's listen address on the Data I/O bus. A comparison is made by the ASM with the device address switches on the DMM. If a match occurs, the listen flip-flop (1/2 of U7) in the GPIB Status Storage is set by the ASM.

5.5.3.2.6 If the GPIB board is in the listen state and ATN returns high, the ASM will handshake any bytes made available over the GPIB. The GPIB board will then send an interrupt to the microprocessor, indicating that a byte is ready for the microprocessor. The microprocessor takes the byte and the ASM sets the Byte Ready line low. When the microprocessor is ready for another byte, it will set the MPU Ready line high and the ASM will transfer another byte of data. Figure 5.37 illustrates the timing relationships.

5.5.3.2.7 When ATN goes low, the GPIB board must respond within 200 nanoseconds. This is accomplished by having ATN reset the four control lines: Not Ready For Data (NRFD), Data Valid (DAV), No Data Accepted (NDAC) and Attention Latch (ATNL). This meets the IEEE-488 Standard and prevents the controller from sending data until the ASM program has a chance to execute the attention routine. The ASM program then starts the handshaking routine.

5.5.3.2.8 If, with ATN low, the ASM recognizes a byte from the controller as being its talk address, the talk flip-flop (1/2 of U7) is set and the ASM handshakes any other interface commands. The microprocessor will recognize the talk state and will take readings in the function called. The data is passed on the microprocessor data bus (D0 through D7) and stored in the GPIB Data Output Latches (U5 and U6). The microprocessor then sets the Next Byte Available (NBA) flip-flop (1/2 of U23), indicating that another data byte is ready. After the ASM outputs the next byte, it resets the NBA flip-flop which signals the microprocessor that it can load another data byte.

5.5.3.2.9 The GPIB Address Switch Read Buffer (U17) is used to provide a front panel display of the address set on the rear panel address switches.

6.1 INTRODUCTION.

6.1.1 This section contains information required to maintain the Model 6000. Signal flow diagrams and test point standards are provided to facilitate performance checks and troubleshooting.

6.1.1.1 For the convenience of the user during maintenance or field installation of options, the Model 6000 has an option label affixed to the transformer cover on the rear panel. It indicates the location of all option assemblies for that unit.

Option	Function	Location of Unique Assy
—	AC rms	Cal Module
—	488 Interface	Mainframe
—	Ohms	Cal Mod./Mainfr.
03SH	H.S. Digitizer	Mainframe
04	50 Hz line	Mainframe
09	Ratio Switch	Cal Module
11	Ref AC rms	Cal Module
14	AC avg	Cal Module
34	4 W Ratio	Cal Module
41	10mV/1Ω	Mainframe
59	BCD interface	Mainframe
60	Rack Mount	Mainframe
66	Slide Mount	Mainframe
71	220/240 line	Mainframe

6.2 CALIBRATION CHECKS AND PROCEDURES.

6.2.1 Detailed procedures for maintaining the calibration specifications of the Model 6000 are contained in the Operators Manual.

6.3 MAINTENANCE DISASSEMBLY.

WARNING

Removal of covers exposes potentially lethal voltages. Avoid contact with internal electrical connections while unit is connected to AC Power source.

6.3.1 Access to the DMM circuitry may be made as follows (reference Figure 6.1):

a. Unplug power cord from AC Power source.

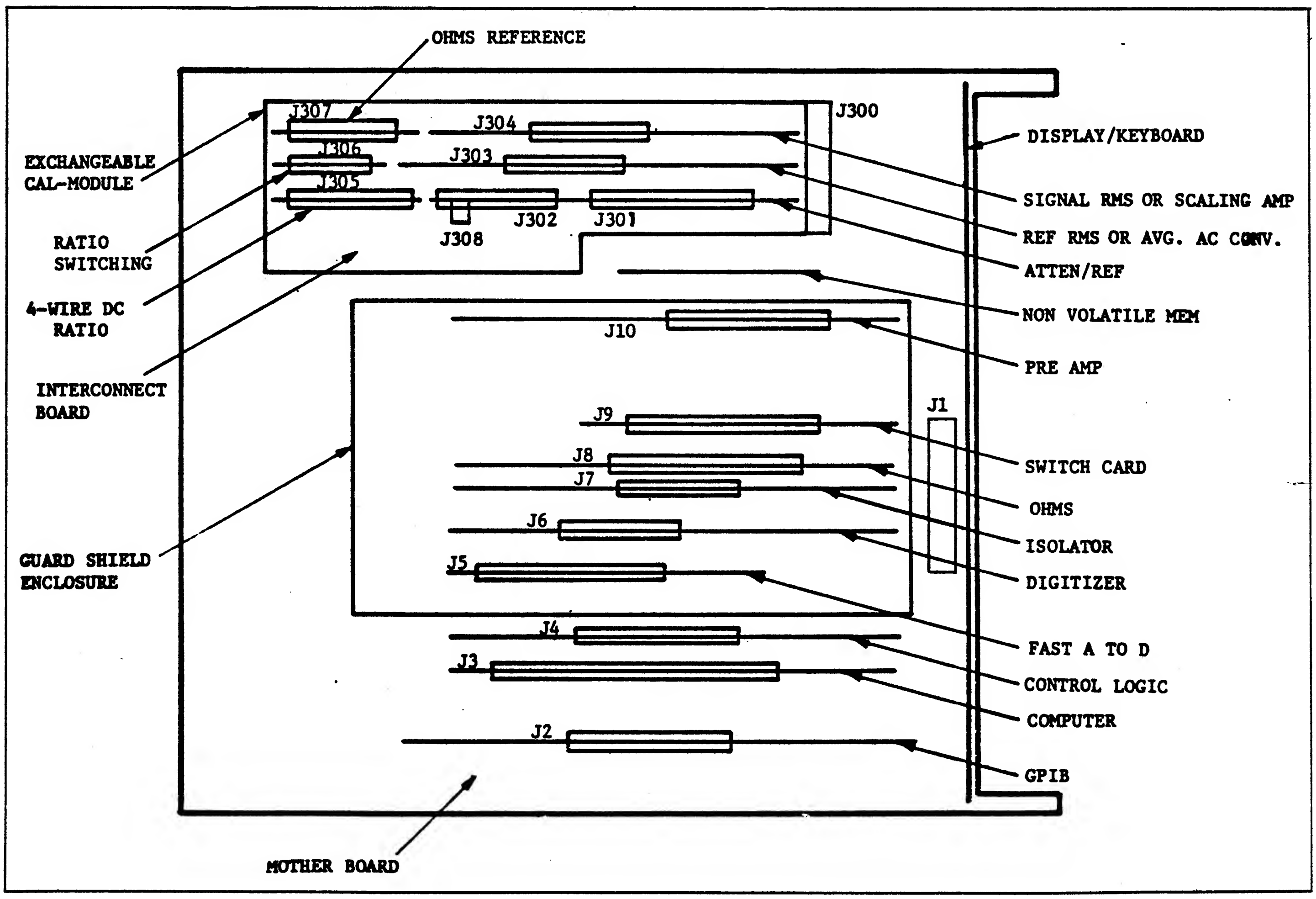


Figure 6.1 - PC Board Locations

Table 6.1 - Recommended Test Equipment

Function	Qty	Item	Minimum Use Specifications	Suggested Equipment
DC	(2)	DC Voltages Sources	0.1 ppm resolution	FLUKE 332B
	(2)	Voltage Divider, Adjustable	0.1 ppm linearity	FLUKE 720A
	(1)	10:1 Voltage Divider, Fixed	1 ppm, Output Z $\leq$ 10 K ohms	ESI RV622, With corrections
AC	(1)	AC Voltage Source	1 ppm resolution	HP745A/746A
OHMS	(8)	Resistance Standards		
		10Ω	10 ppm	ESI SR1 with corrections
		100Ω	5 ppm	ESI SR1 with corrections
		1KΩ	5 ppm	ESI SR1 with corrections
		10KΩ	5 ppm	ESI SR1 with corrections
		100KΩ	5 ppm	ESI SR1 with corrections
		1MΩ	5 ppm	ESI SR1 with corrections
		10MΩ	20 ppm	ESI SR1 with corrections
		100MΩ	80 ppm	Fabricated
Other	(1)	Digital Voltmeter, 5 1/2 Digits	Input R $\geq$ 10,000 MΩ on 10VDC Range	Racal-Dana 6000 or 5900
	(1)	Oscilloscope	50 MHz Bandwidth 5mV/cm Sensitivity	Tektronix 454

b. Remove the instrument top cover by loosening the four securing screws.

c. Remove the guard shield top cover by loosening the four securing screws.

d. Loosen the rear panel thumbscrew that secures the Cal-Module.

e. Slide the Cal-Module out of the Model 6000.

f. Remove the Cal-Module top cover by loosening the five securing screws.

g. Slide the Cal-Module back into the Model 6000 and tighten the rear panel thumbscrew.

6.3.2 PC Board Removal.

6.3.2.1 All of the printed circuit boards (except the Non-Volatile Memory board and Display board) may be unplugged from the motherboard connectors as required.

6.3.2.2 NON-VOLATILE MEMORY BOARD REMOVAL.

6.3.2.2.1 The Non-Volatile Memory board may be removed as follows:

a. Remove the Cal-Module by loosening the thumbscrew on the rear panel. Slide the Cal-Module out of the Model 6000.

b. Remove the Non-Volatile Memory board by loosening the four securing screws.

6.3.2.3 DISPLAY BOARD REMOVAL.

6.3.2.3.1 The Display board may be removed as follows:

a. Remove the four top and five bottom front panel assembly securing screws.

b. Remove the front panel assembly from the 6000. Take care not to put excessive stress on the wires connected to the AC Power switch.

c. Remove the Display board from the front panel assembly by loosening the six securing screws.

6.4 UNIT PERFORMANCE CHECKS.

WARNING

Removal of covers exposes potentially lethal voltages. Avoid contact with internal electrical connections while unit is connected to AC Power source.

6.4.1 This section contains unit performance checks for each basic function and range of the Model 6000. Signal flow diagrams and test point standards are also provided to facilitate troubleshooting.

6.4.2 Test points called out in the performance checks may refer to physical test points provided in the circuitry or to component connections. The test point identifiers appear in the performance check tables as black squares (voltage test points) and black diamonds (waveform test points).

6.4.3 Subassembly performance checks are designed to aid in the isolation of malfunctioning components. Test points are numbered and lettered sequentially for each board so that the signal may be traced from the input to the output of the board.

6.4.4 Recommended Test Equipment.

6.4.4.1 Test equipment recommended for performance checks and troubleshooting is listed in Table 6.1. Equivalent test equipment may be substituted, where desired.

6.4.4.2 CALIBRATION/MAINTENANCE TEST BED.

6.4.4.2.1 The Calibration/Maintenance Test Bed may be used to facilitate calibration, troubleshooting and repair of plug-in circuit boards and the Cal-Module. The Test Bed is electronically identical to the Model 6000 (except for the absence of a Cal-Module) and the front panel is designed to simplify maintenance procedures. A complete description of the Test Bed is contained in the Operators Manual.

6.4.5 Power Supply Check.

6.4.5.1 Before proceeding with the unit performance checks, ensure that the various power supply voltages are present and correct (reference Table 6.2). If a discrepancy is found, reference the test procedures in the following paragraphs.

6.4.5.2 NO SUPPLY VOLTAGES.

6.4.5.2.1 Ensure that the AC power cord is connected to the proper voltage source and that the front panel power switch is set ON. If all supplies still remain at zero, proceed as follows:

a. Disconnect the AC power cord from the power source.

b. Remove the fuse from the rear panel fuseholder and check its condition with an ohmmeter. If the fuse is open, replace with one of the proper rating for the selected operating voltage, and place back in the fuseholder.

c. Reconnect the AC power cord and recheck the supply voltages. If the problem persists, check the power supply components.

6.4.5.3 INCORRECT SUPPLY VOLTAGES.

6.4.5.3.1 Ensure that the AC power cord is connected to the proper voltage source. If incorrect supply voltages are still noted, proceed as follows:

a. Disconnect the AC power cord from the power source.

b. Remove all plug in boards to eliminate possible source of shorts.

c. Reconnect the AC power and recheck the supply voltages. If voltages return to proper levels, check the plug in boards for shorts. If the voltages do not return to normal levels, check the Motherboard circuitry for shorts and the power supply for bad components.

6.4.6 Error Messages.

NOTE

The Series 6000 contains two sets of error limits for readings taken during Auto-Cal.

Errors 61 thru 76 are Predictive Maintenance errors and **do not** indicate an operating condition that is out-of tolerance. They indicate instead that the Auto-Cal sequence has corrected for conditions that are beyond the normal design tolerances expected with the Series 6000. To prevent possible future failure or performance that is out-of-specification, the unit should be referred for maintenance when convenient.

Errors 81 thru 96 indicate a failure or a condition that is out-of-specification, and with the unit "locking-up" on the first error encountered.

Additional diagnostic errors may be observed by pressing any key on the Series 6000 keyboard.

6.4.6.1 Error messages and their descriptions are listed in Table 6.3. References are made in the Auto-Cal message descriptions to the singlethread troubleshooting diagrams in Figures 6.3 thru 6.17. These diagrams, in conjunction with the function unit performance tests in Tables 6.9 and 6.10, will aid in the location of defective circuitry. In the event that a lockup condition occurs (error messages 81 thru 99), the lockup may be bypassed, for troubleshooting purposes, by pressing any key on the Model 6000 keyboard.

6.4.7 Troubleshooting Charts.

6.4.7.1 The following troubleshooting charts are presented as an aid in the isolation of malfunctions to individual sub-assemblies. References are made in the charts to the unit performance tests for these subassemblies.

Table 6.2 - Power Supply Checks

Input and Control Setting	Signal Nomenclature	Reference Designation	Test Point	Illustration Reference	Performance Standard
Power Switch On	All digital supplies are referenced to Digital Ground. All analog supplies are referenced to MECCA.				
	Display +5V output	U1-3	1	Figure 6.2	Voltage level varies according to display load
	M.B. +5V output	E43	2	Figure 6.2	+5V
	TTL +5	E34	3	Figure 6.2	+5V
	Calibration memory −30V output	Q1-1	4	Figure 6.2	−30V
	Analog +5V output	U14-3	5	Figure 6.2	+5V
	Analog +15V output	U15-3	6	Figure 6.2	+15V
	Analog −15V output	U12-3	7	Figure 6.2	−15V
	Analog +30V UNREG output	U11-1	8	Figure 6.2	+30V to +45V
	Relay Coil +24V output	U11-3	8	Figure 6.2	+24V
	Analog −30V UNREG	U13-2	9	Figure 6.2	−30V to −45V
	Analog −24V output	U13-3	9	Figure 6.2	−24V
	Analog −40V	CR3, CR4	10	Figure 6.2	−40 to −85V

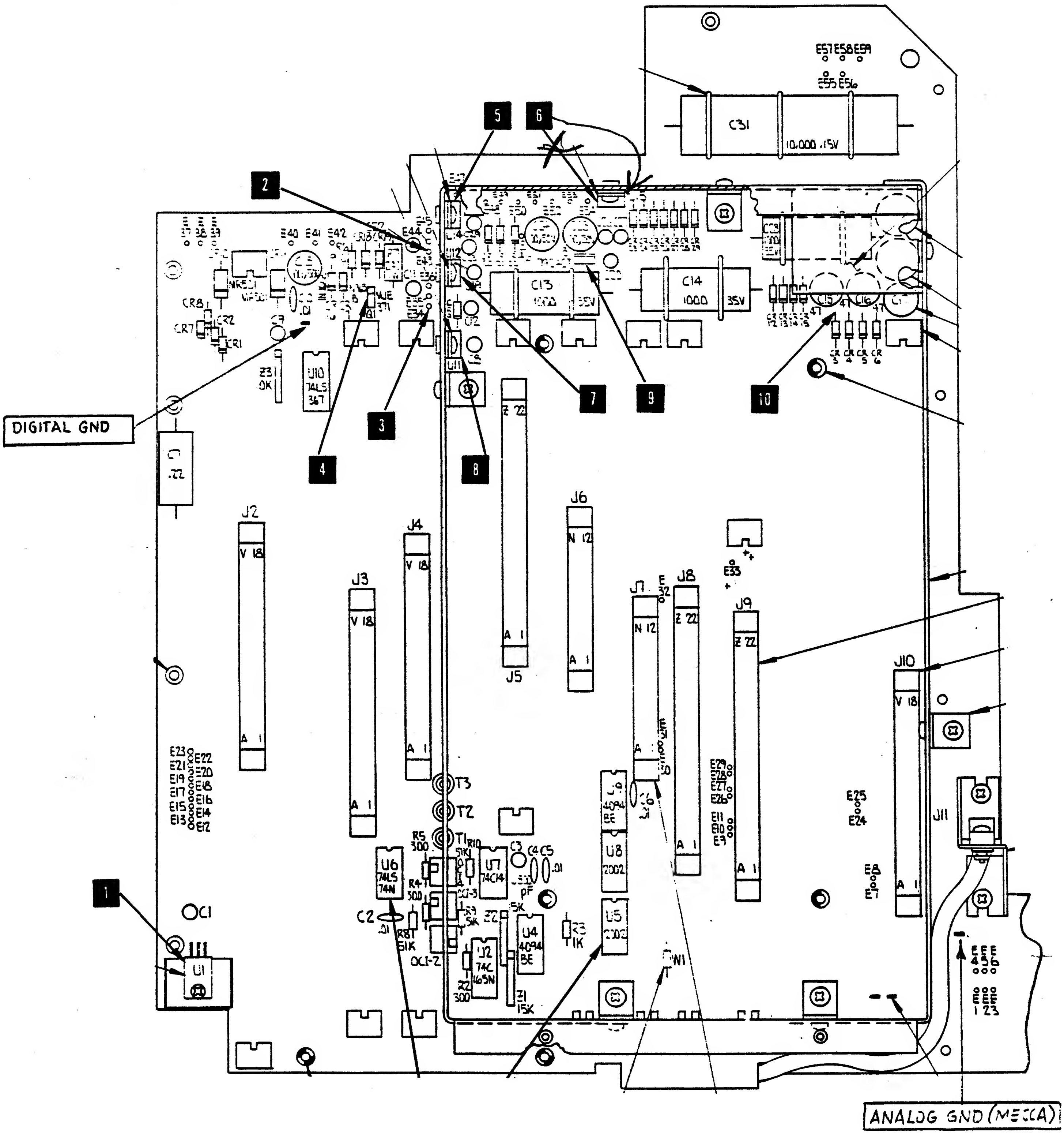


Figure 6.2 - Main Logic Component Location Diagram

Table 6.3 - Error Messages

Error Number	Description
0	Cannot calculate Log of zero
2	Attempted Auto-cal when in 1000V signal or reference range
10	Improper Key sequence
11	Illegal # digits request
12	Divide by zero
13	Exponent cannot be displayed when in 6 1/2 digit mode
14	Display exponent beyond ± 9
20	Required board missing from main analog section
21	Required board missing from CAL module
22	Signal RMS converter not installed
23	Reference RMS converter not installed
24	AC converter not installed
25	Ohms converter not installed
26	4-wire DC external reference not installed
29	Fast Digitizer not installed
30	RAM failure on computer board
31	DC or reference Non Vol number out of spec
32	Ohms Non Vol number out of spec
33	Non Vol will not write or Cal switch bad
34	Clock on Non Vol board not oscillating
35	Reading will not trigger on control logic board
36	No axis crossing detected from Integrator board
	PREDICTIVE MAINTENANCE ERRORS (See Tables 6.4 to 6.8)
	Auto-Cal reading taken during:
61	DC CAL 1 (Isolator/Digitizer - Positive Reference Voltage - See Figure 6.12)
62	DC CAL 2 (Attenuator - Positive Reference Voltage - See Figure 6.13)
63	DC CAL 3 (Isolator/Digitizer - Negative Reference Voltage - See Figure 6.14)
64	DC CAL 4 (Attenuator - Negative Reference Voltage - See Figure 6.15)
65	DC CAL 5 (10 Volt Range - See Figure 6.3)
66	DC CAL 6 (1 Volt Range - See Figure 6.4)
67	DC CAL 7 (100 mV Range - See Figure 6.4)
68	DC CAL 8 (10mV Range - See Figure 6.6)
71	OH CAL 1 (10Ω Range - See Figure 6.9)
72	OH CAL 2 (100Ω, 1KΩ Ranges - See Figure 6.8)
73	OH CAL 3 (10KΩ - 100MΩ Ranges - See Figure 6.7)
74	OH CAL 4 (Input Bias Current - See Figure 6.16)
75	OH CAL 5 (Internal 10K Reference Resistor - See Figure 6.17)
76	OH CAL 6 (1Ω Range - See Figure 6.10)

Table 6.3 - Error Messages continued

Error Number	Description
	DIAGNOSTIC ERRORS (See Tables 6.4 to 6.8)
	Incorrect Auto-Cal reading taken during:
81	DC CAL 1 (Isolator/Digitizer - Positive Reference Voltage - See Figure 6.12)
82	DC CAL 2 (Attenuator - Positive Reference Voltage - See Figure 6.13)
83	DC CAL 3 (Isolator/Digitizer - Negative Reference Voltage - See Figure 6.14)
84	DC CAL 4 (Attenuator - Negative Reference Voltage - See Figure 6.15)
85	DC CAL 5 (10 Volt Range - See Figure 6.3)
86	DC CAL 6 (1 Volt Range - See Figure 6.4)
87	DC CAL 7 (100mV Range - See Figure 6.4)
88	DC CAL 8 (10mV Range - See Figure 6.6)
91	OH CAL 1 (10Ω Range - See Figure 6.9)
92	OH CAL 2 (100Ω, 1KΩ Ranges - See Figure 6.8)
93	OH CAL 3 (10KΩ - 100MΩ Ranges - See Figure 6.7)
94	OH CAL 4 (Input Bias Current - See Figure 6.16)
95	OH CAL 5 (Internal 10K Reference Resistor - See Figure 6.17)
96	OH CAL 6 (1Ω Range - See Figure 6.10)

Table 6.4 - Troubleshooting Chart - General

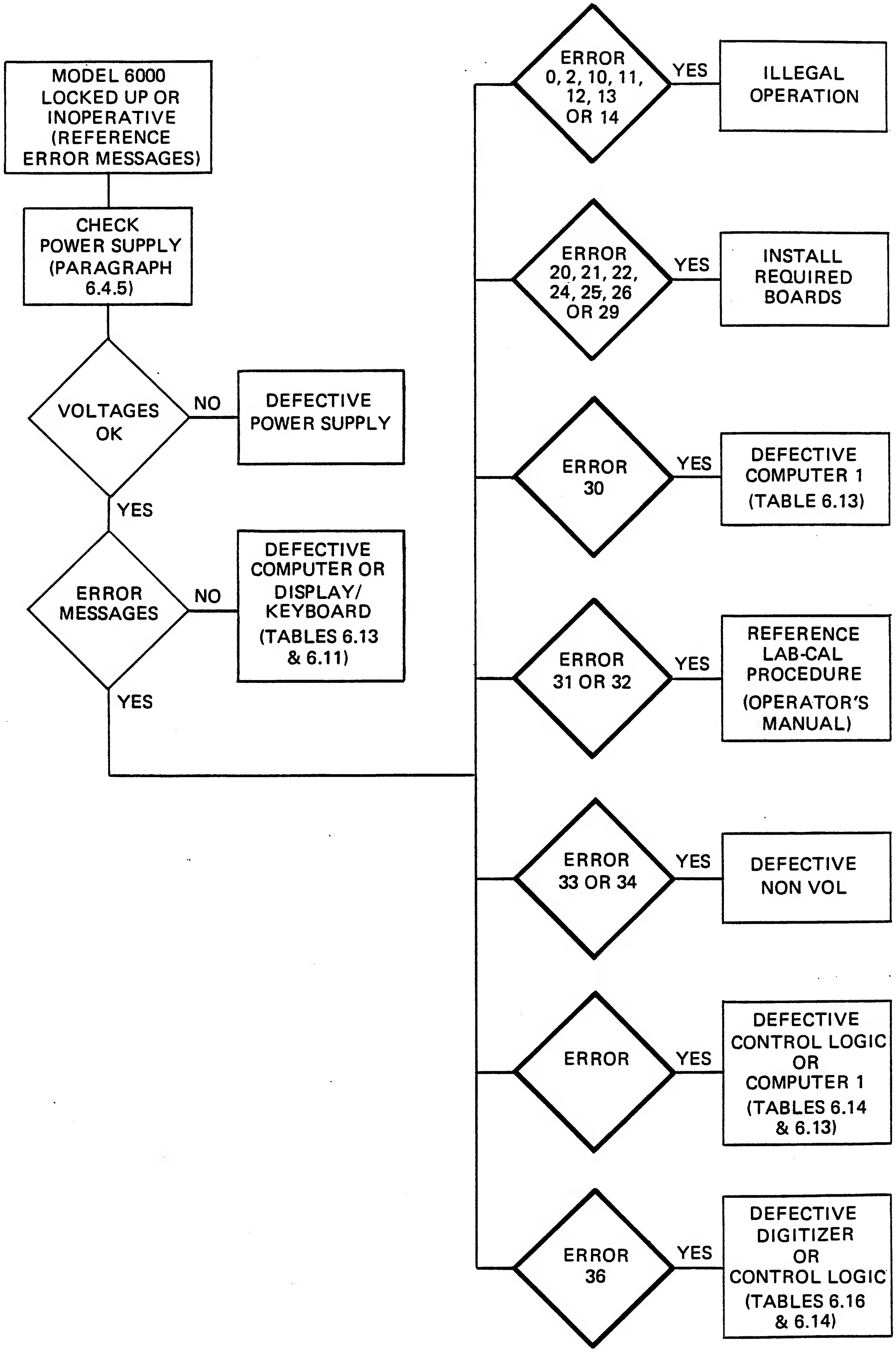


Table 6.5 - Troubleshooting Chart - DC Voltage

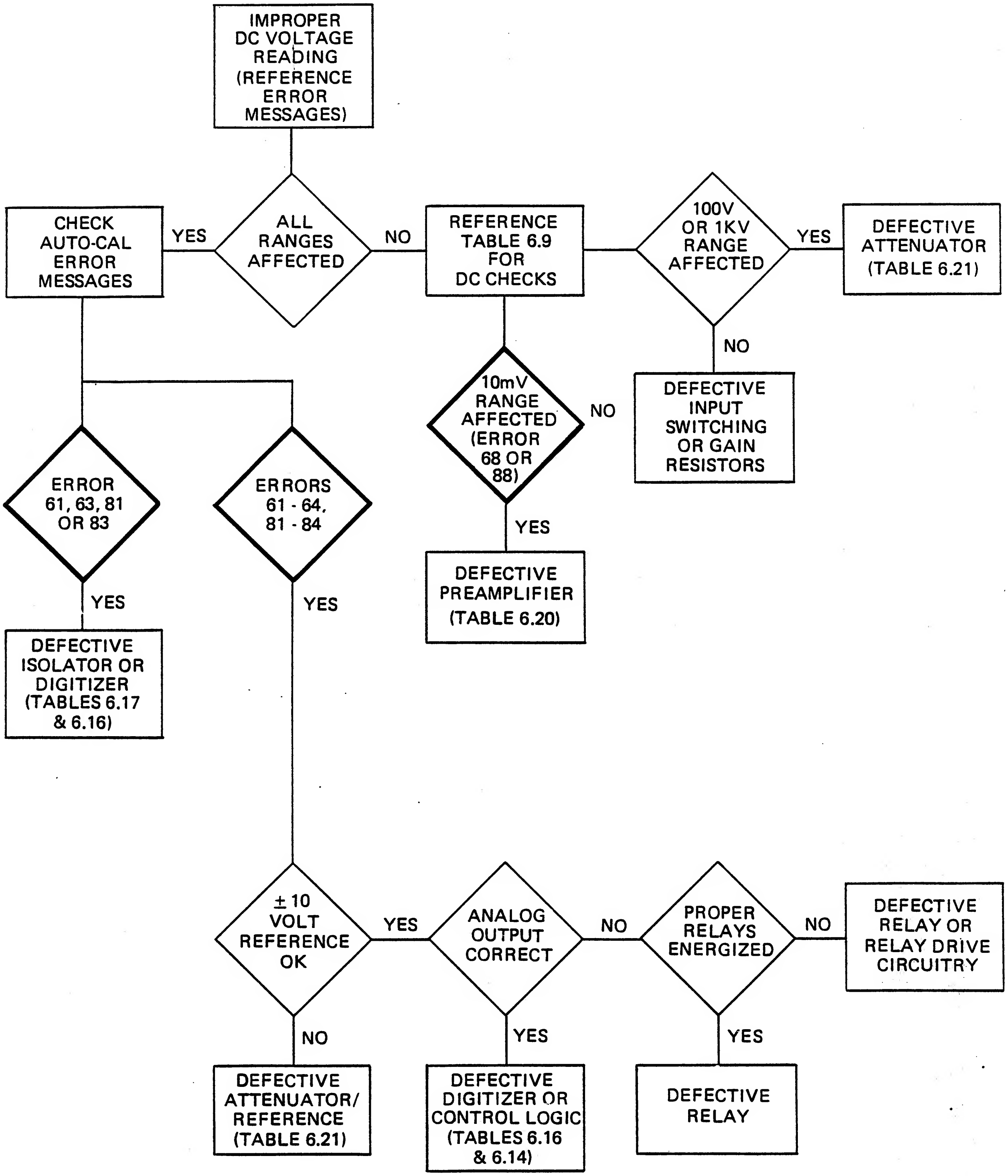


Table 6.6 - Troubleshooting Chart - AC Voltage

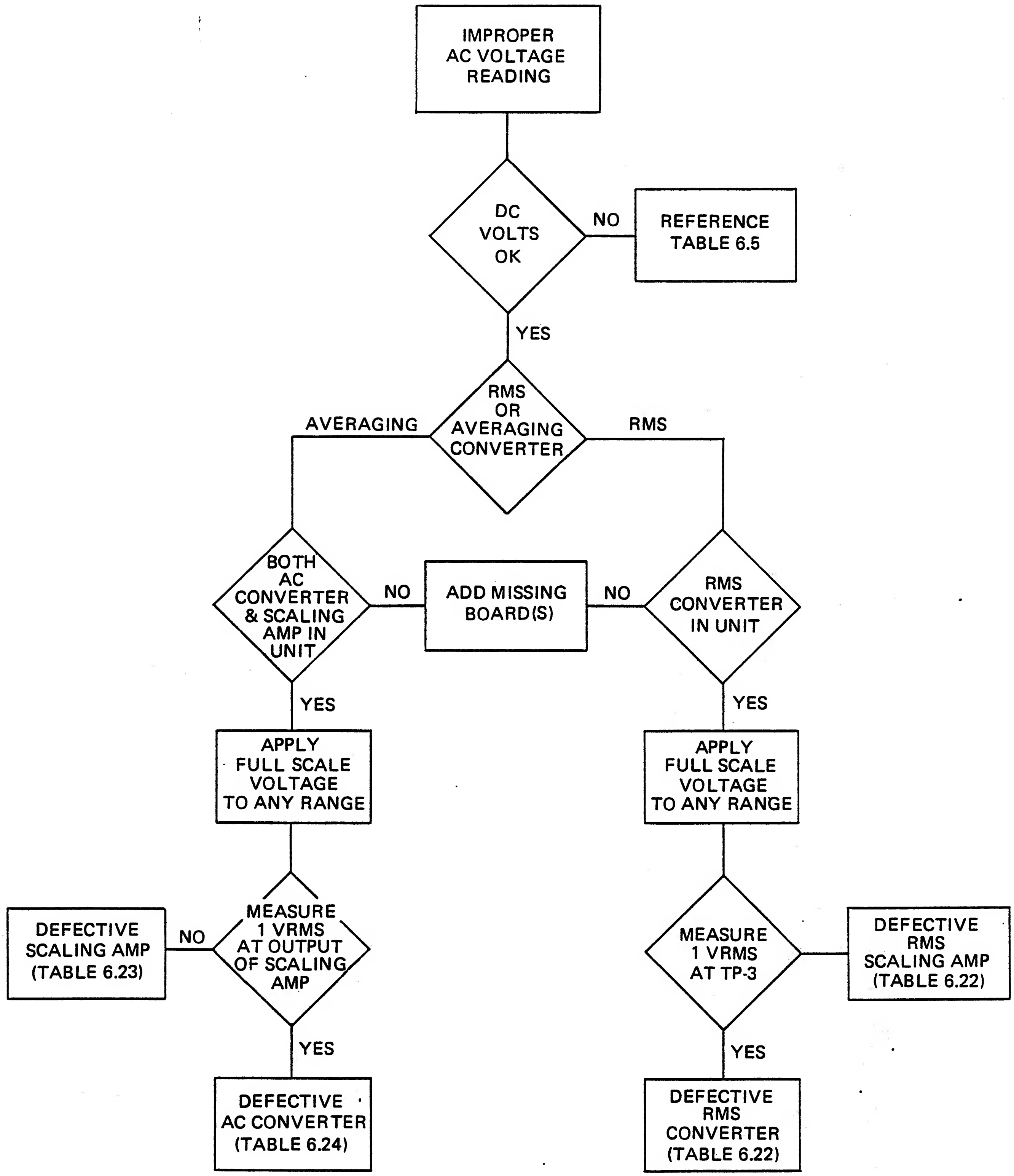


Table 6.7 - Troubleshooting Chart - Ohms

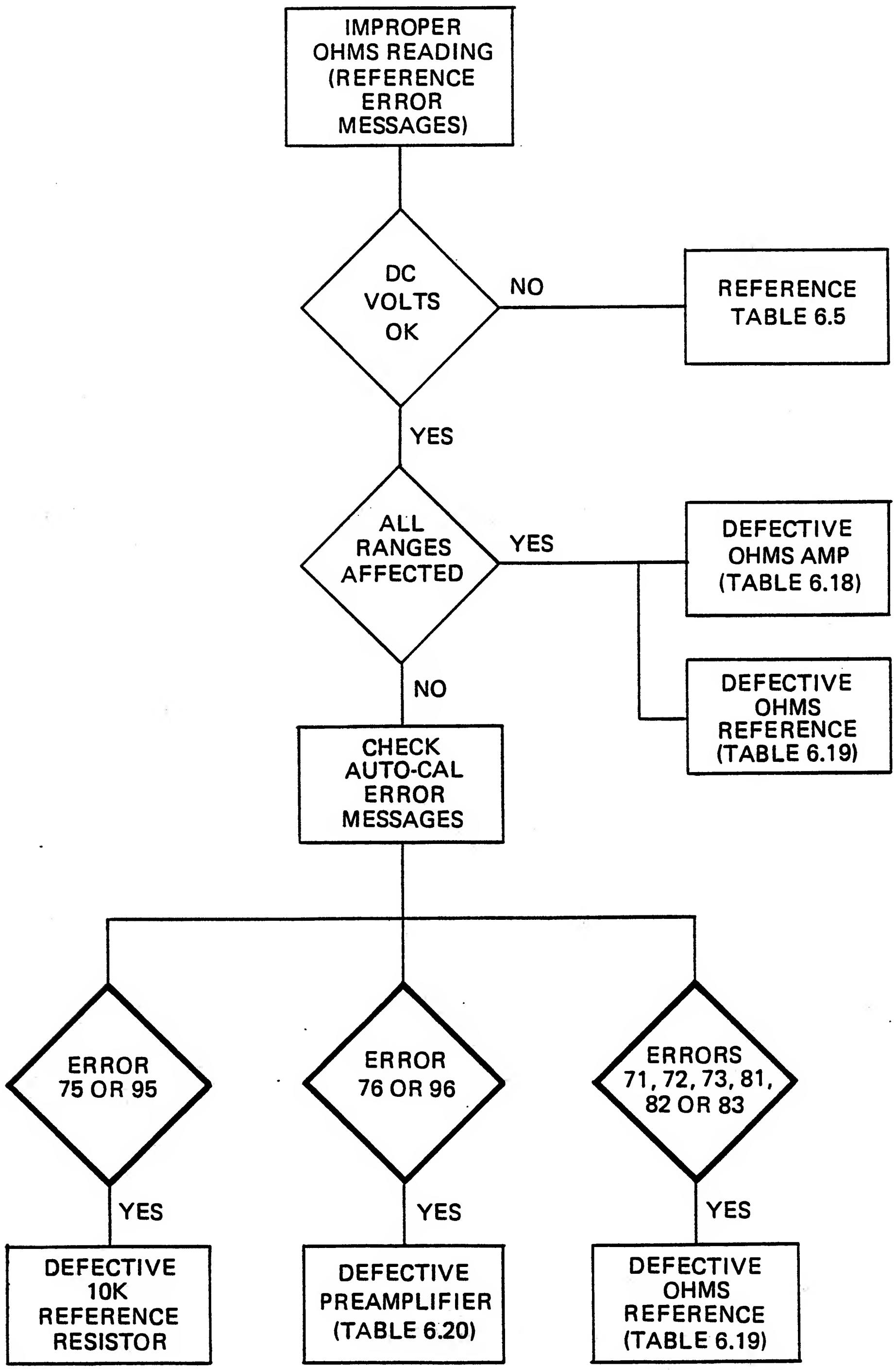


Table 6.8 - Troubleshooting Chart - Remote Programming

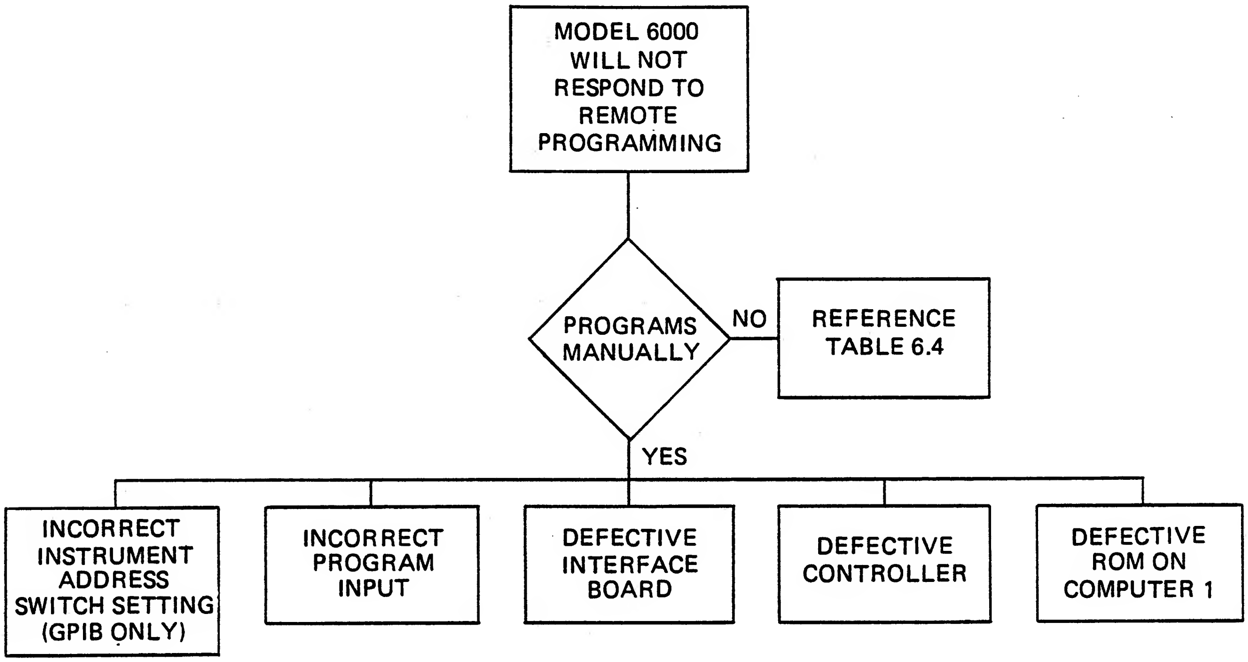


Table 6.9 - DC Voltage Unit Performance Tests

Input and Control Setting	Signal Nomenclature	Reference Designation	Test Point	Illustration Reference	Performance Standard
	All measurements are referenced to Analog Common (Mecca).				
Function: DC Voltage Range: 10 VDC Input: 10 VDC	Isolator + input	J7-A	1	Figure 6.3	+10.0 VDC
	Isolator – input	TP1	2	Figure 6.3	+10.0 VDC
	Isolator output	TP2	3	Figure 6.3	+10.0 VDC
Function: DC Voltage Range: 100 mVDC Input: 100 mVDC	Isolator + input	J7-A	1	Figure 6.4	+0.1 VDC
	Isolator – input	TP1	2	Figure 6.4	+0.1 VDC
	Isolator output	TP2	3	Figure 6.4	+10.0 VDC
Function: DC Voltage Range: 1 VDC Input: 1 VDC	Isolator + input	J7-A	1	Figure 6.4	+1.0 VDC
	Isolator – input	TP1	2	Figure 6.4	+1.0 VDC
	Isolator output	TP2	3	Figure 6.4	+10.0 VDC
Function: DC Voltage Range: 100 VDC Input: 100 VDC	Isolator + input	J7-A	1	Figure 6.5	+10.0 VDC
	Isolator – input	TP1	2	Figure 6.5	+10.0 VDC
	Isolator output	TP2	3	Figure 6.5	+10.0 VDC

Table 6.9 - DC Voltage Unit Performance Tests (Continued)

Input and Control Setting	Signal Nomenclature	Reference Designation	Test Point	Illustration Reference	Performance Standard
Function: DC Voltage Range: 1000 VDC Input: 1000 VDC					
	Isolator + input	J7-A	1	Figure 6.5	+10.0 VDC
	Isolator – input	TP1	2	Figure 6.5	+10.0 VDC
	Isolator output	TP2	3	Figure 6.5	+10.0 VDC
Function: DC Voltage Range: 10 mVDC Input: 10 mVDC					
	Isolator + input	J7-A	1	Figure 6.6	+7.2 VDC
	Isolator – input	TP1	2	Figure 6.6	+7.2 VDC
	Isolator output	TP2	3	Figure 6.6	+7.2 VDC
	Preamplifier + input	E4	4	Figure 6.6	+10 mVDC
	Preamplifier output	E3	5	Figure 6.6	+7.2 VDC
	Preamplifier – input	E7	6	Figure 6.6	+10 mVDC

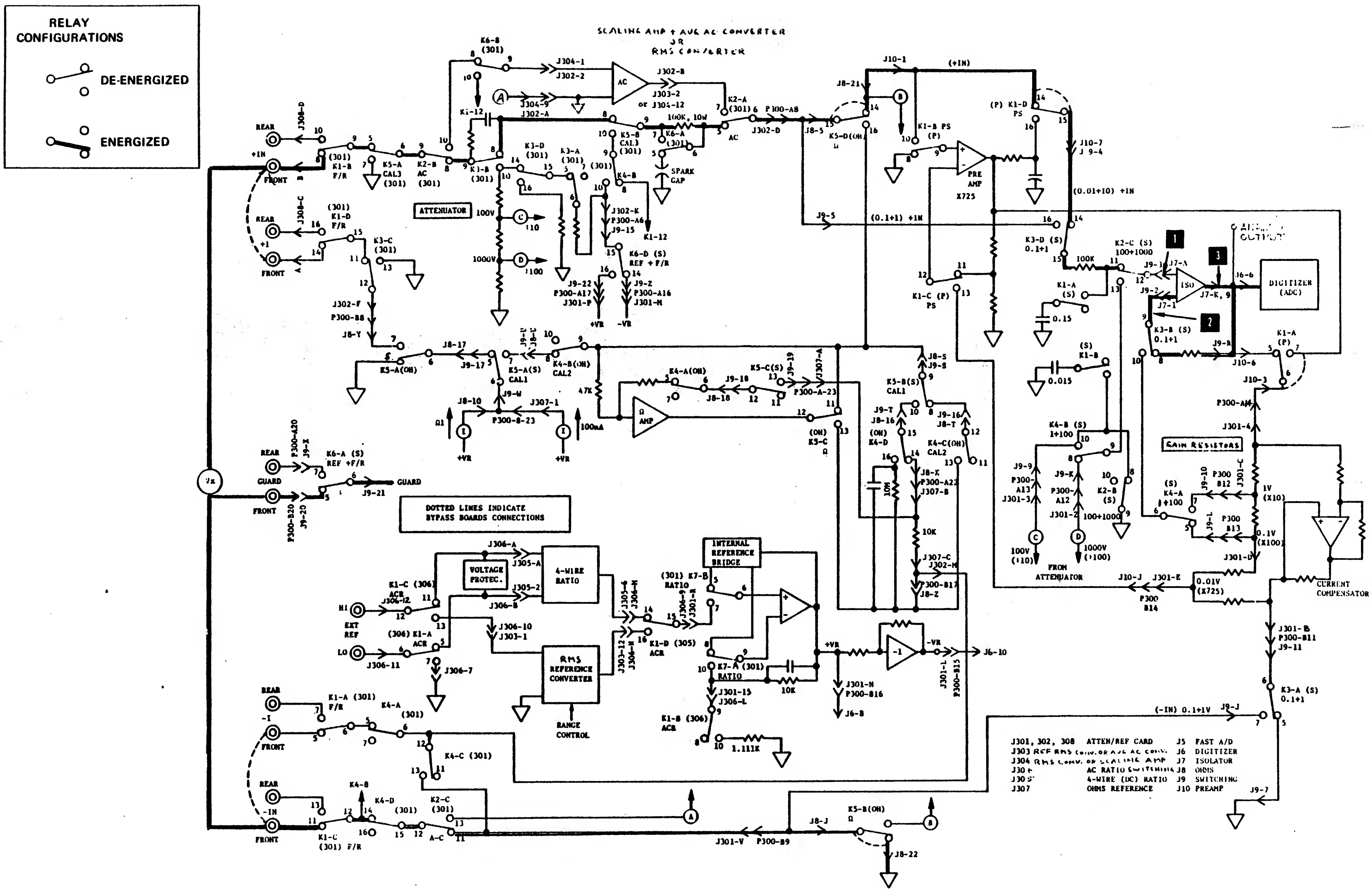


Figure 6.3 - 10 Volt DC Range Singlethread Troubleshooting Diagram

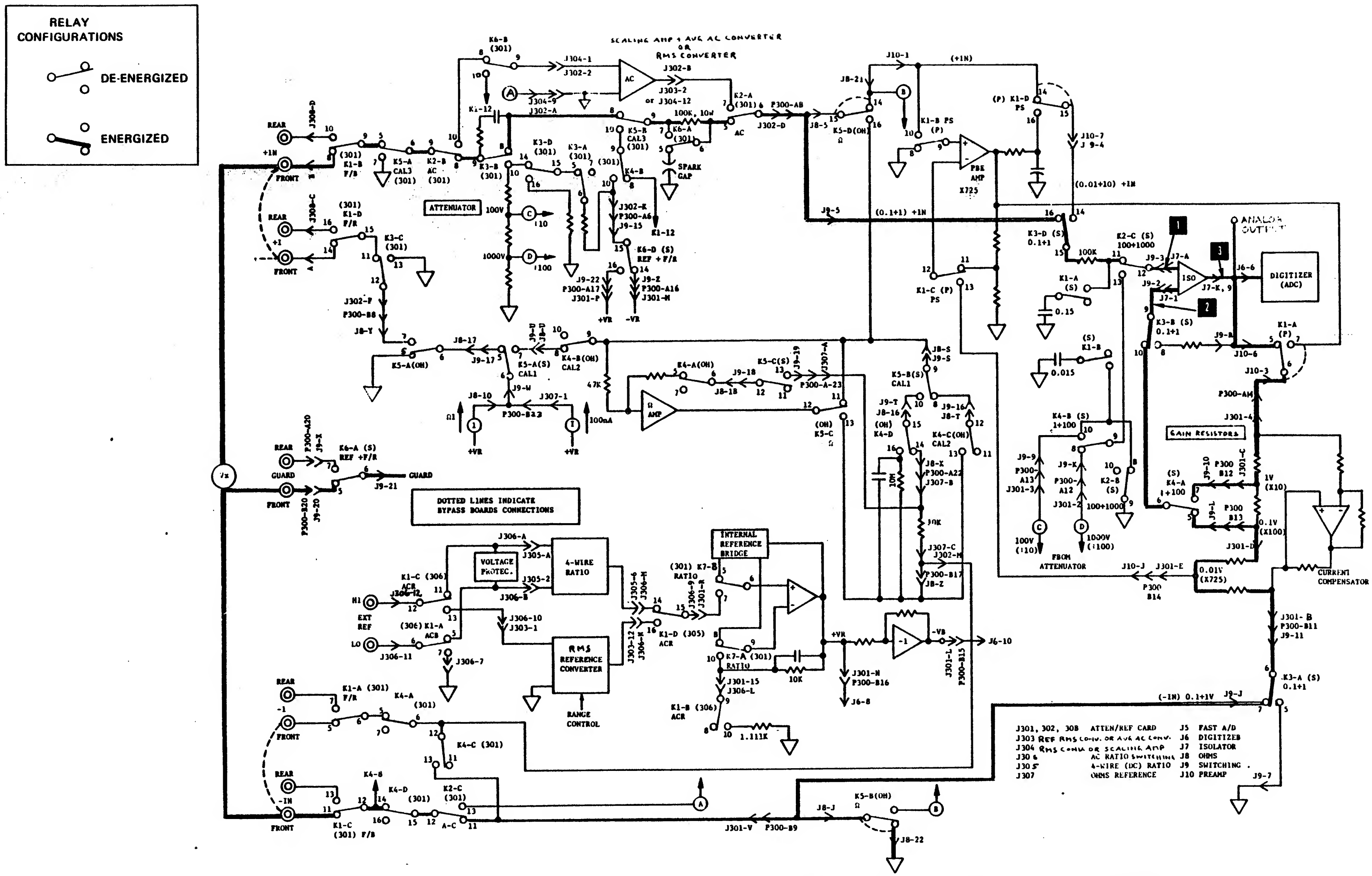


Figure 6.4 - 100mV and 1 Volt DC Range Singlethread Troubleshooting Diagram

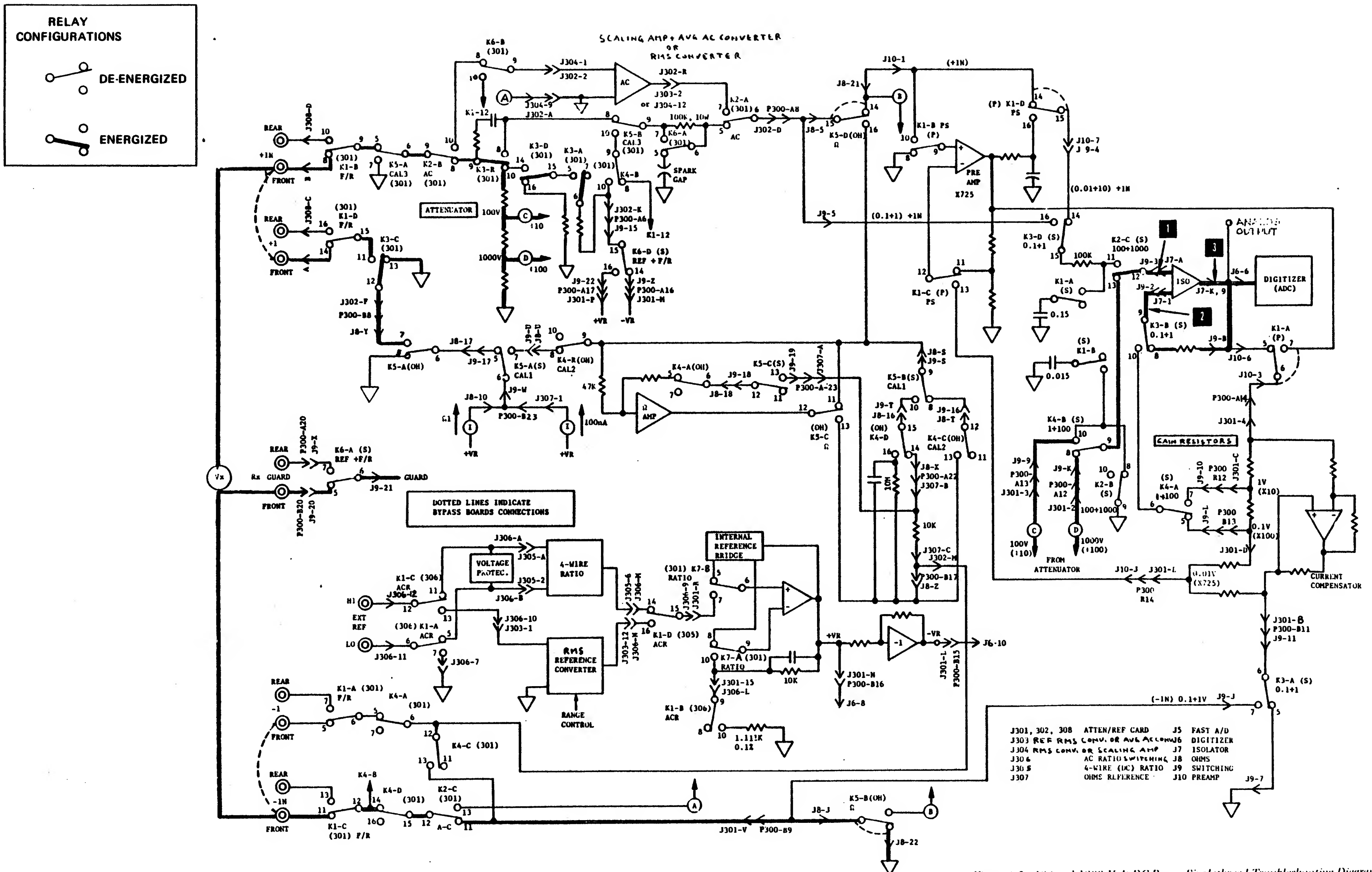


Figure 6.5 - 100 and 1000 Volt DC Range Singlethread Troubleshooting Diagram

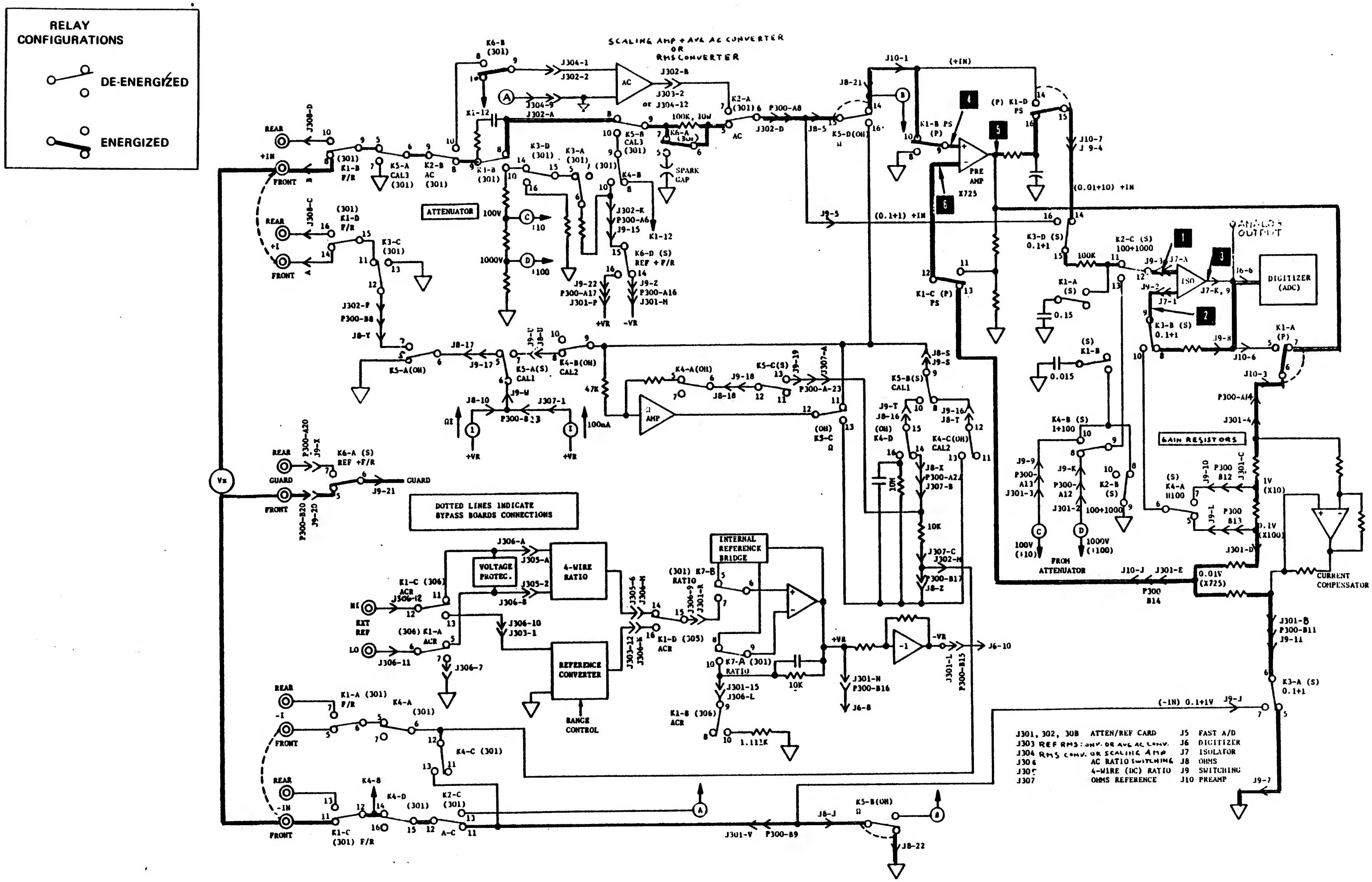


Figure 6.6 - 10mV DC Range Singlethread Troubleshooting Diagram

Table 6.10 - Ohms Range Unit Performance Tests

Input and Control Setting	Signal Nomenclature	Reference Designation	Test Point	Illustration Reference	Performance Standard
Function: Ohms Range: 10KΩ Connect 10KΩ Resistor in 4-Wire Hook-Up	All measurements are referenced to Analog Common (Mecca).				
	Ohms Amplifier output	TP4	1	Figure 6.7	–10.0 VDC
	Ohms Amplifier input	TP5	2	Figure 6.7	0.0 VDC (nominal)
	Isolator – input	TP1	3	Figure 6.7	–10.0 VDC
	Isolator output	TP2	4	Figure 6.7	–10.0 VDC
	Isolator + input	J7-A	5	Figure 6.7	–10.0 VDC
Function: Ohms Range: 100KΩ Connect 100KΩ Resistor in 4-Wire Hook-Up					
	Ohms Amplifier output	TP4	1	Figure 6.7	–10.0 VDC
	Ohms Amplifier input	TP5	2	Figure 6.7	0.0 VDC (nominal)
	Isolator - input	TP1	3	Figure 6.7	–10.0 VDC
	Isolator output	TP2	4	Figure 6.7	–10.0 VDC
	Isolator + input	J7-A	5	Figure 6.7	–10.0 VDC
Function: Ohms Range: 1MΩ Connect 1MΩ Resistor in 4-Wire Hook-Up					
	Ohms Amplifier output	TP4	1	Figure 6.7	–10.0 VDC
	Ohms Amplifier input	TP5	2	Figure 6.7	0.0 VDC (nominal)
	Isolator – input	TP1	3	Figure 6.7	–10.0 VDC
	Isolator output	TP2	4	Figure 6.7	–10.0 VDC
	Isolator + input	J7-A	5	Figure 6.7	–10.0 VDC

Table 6.10 - Ohms Range Unit Performance Tests (Continued)

Input and Control Setting	Signal Nomenclature	Reference Designation	Test Point	Illustration Reference	Performance Standard
Function: Ohms Range: 10MΩ Connect 10MΩ Resistor in 4-Wire Hook-Up					
	Ohms Amplifier output	TP4	1	Figure 6.7	−10.0 VDC
	Ohms Amplifier input	TP5	2	Figure 6.7	0.0 VDC (nominal)
	Isolator – input	TP1	3	Figure 6.7	−10.0 VDC
	Isolator output	TP2	4	Figure 6.7	−10.0 VDC
	Isolator + input	J7-A	5	Figure 6.7	−10.0 VDC
Function: Ohms Range: 100MΩ Connect 100MΩ Resistor in 4-Wire Hook-Up					
	Ohms Amplifier output	TP4	1	Figure 6.7	−10.0 VDC
	Ohms Amplifier input	TP5	2	Figure 6.7	0.0 VDC (nominal)
	Isolator – input	TP1	5	Figure 6.7	−10.0 VDC
	Isolator output	TP2	4	Figure 6.7	−10.0 VDC
	Isolator + input	J7-A	5	Figure 6.7	−10.0 VDC
Function: Ohms Range: 100Ω Connect 100Ω Resistor in 4-Wire Hook-Up					
	Ohms Amplifier output	TP4	1	Figure 6.8	−1.0 VDC
	Ohms Amplifier input	TP5	2	Figure 6.8	0.0 VDC (nominal)
	Isolator – input	TP1	3	Figure 6.8	0.0 VDC (nominal)
	Isolator output	TP2	4	Figure 6.8	+10.0 VDC
	Isolator + input	J7-A	5	Figure 6.8	0.0 VDC (nominal)

Table 6.10 - Ohms Range Unit Performance Tests (Continued)

Input and Control Setting	Signal Nomenclature	Reference Designation	Test Point	Illustration Reference	Performance Standard
Function: Ohms Range: 1KΩ Connect 1KΩ Resistor in 4-Wire Hook-Up	Ohms Amplifier output	TP4	1	Figure 6.8	−1.0 VDC
	Ohms Amplifier input	TP5	2	Figure 6.8	0.0 VDC (nominal)
	Isolator – input	TP1	3	Figure 6.8	0.0 VDC (nominal)
	Isolator + output	TP2	4	Figure 6.8	+10.0 VDC
	Isolator input	J7-A	5	Figure 6.8	0.0 VDC (nominal)
Function: Ohms Range: 10Ω Connect 10Ω Resistor in 4-Wire Hook-Up	Ohms Amplifier output	TP4	1	Figure 6.9	−0.1 VDC
	Ohms Amplifier input	TP5	2	Figure 6.9	0.0 VDC (nominal)
	Isolator – input	TP1	3	Figure 6.9	0.00 VDC (nominal)
	Isolator output	TP2	4	Figure 6.9	+10.0 VDC
	Isolator + input	J7-A	5	Figure 6.9	0.0 VDC (nominal)
Function: Ohms Range: 1Ω Connect 1Ω Resistor in 4-Wire Hook-Up	Ohms Amplifier output	TP4	1	Figure 6.10	−10.0 mVDC
	Ohms Amplifier input	TP5	2	Figure 6.10	0.0 VDC
	Isolator – input	TP1	3	Figure 6.10	−7.2 VDC
	Isolator output	TP2	4	Figure 6.10	−7.2 VDC
	Isolator + input	J7-A	5	Figure 6.10	−7.2 VDC

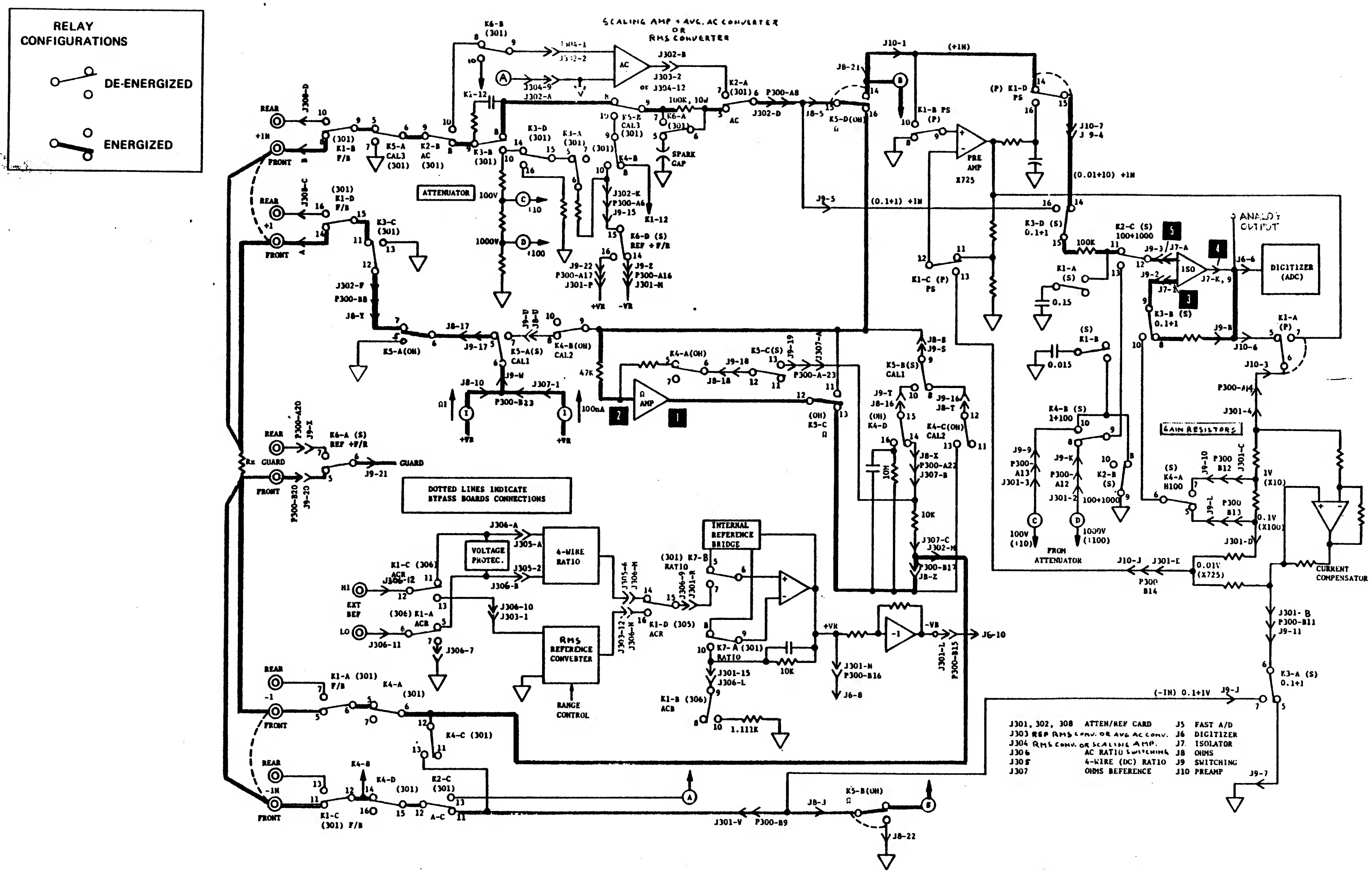


Figure 6.7 - 10K, 100K, 1M, 10M, 100M Ranges Singlethread Troubleshooting Diagram

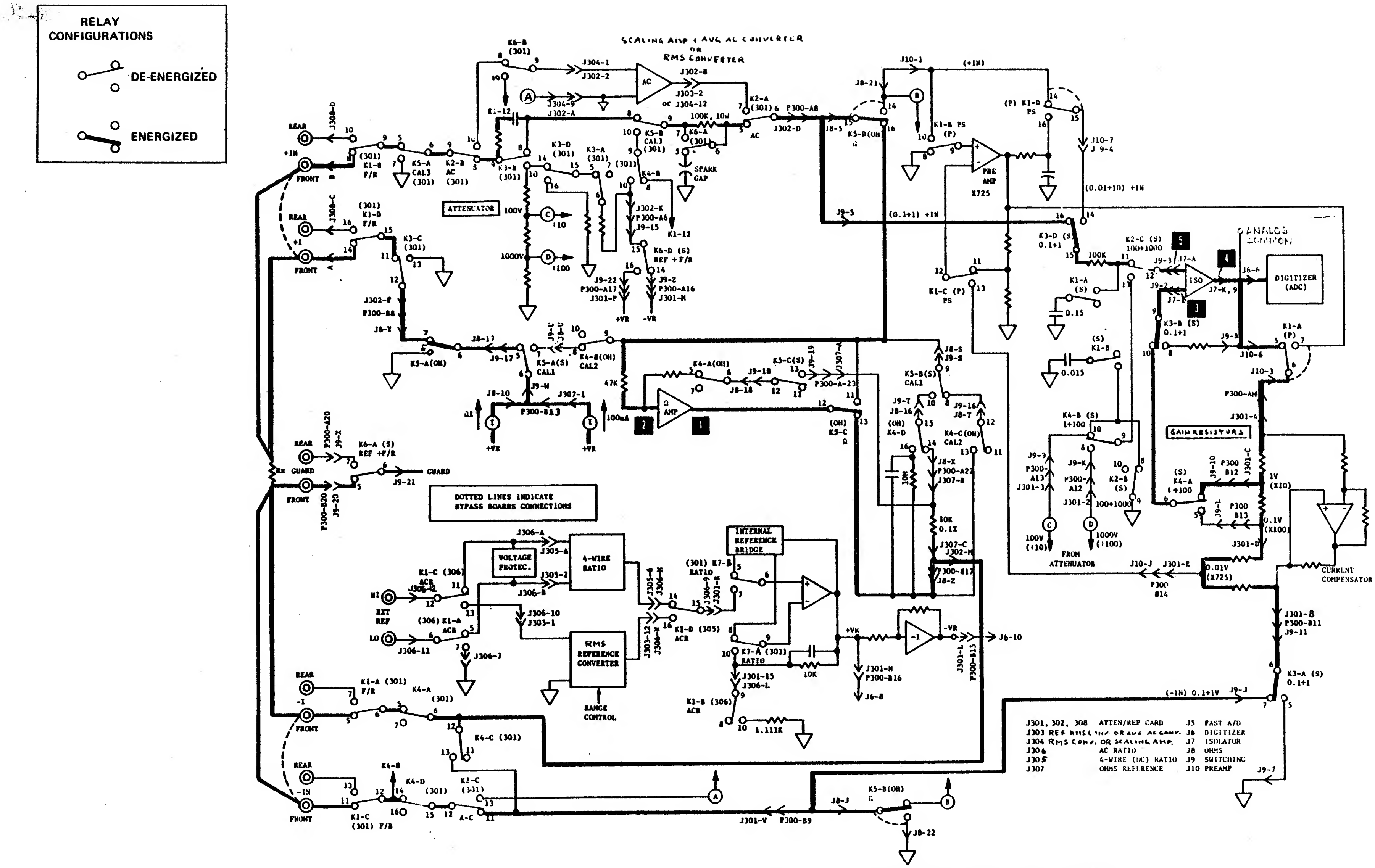


Figure 6.8 - 100, 1K Ohm Ranges Singlethread Troubleshooting Diagram

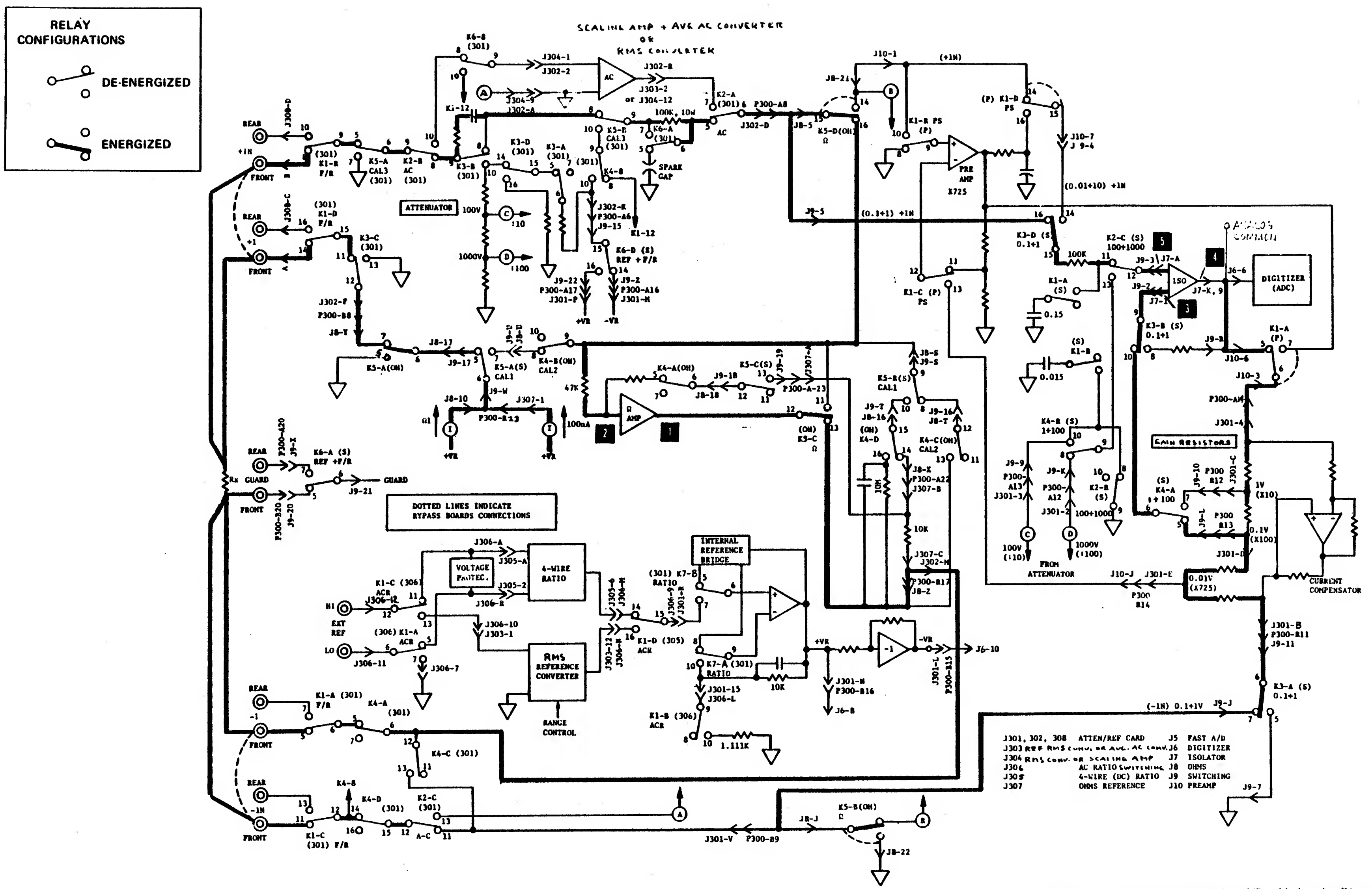


Figure 6.9 - 10 Ohm Range Singlethread Troubleshooting Diagram

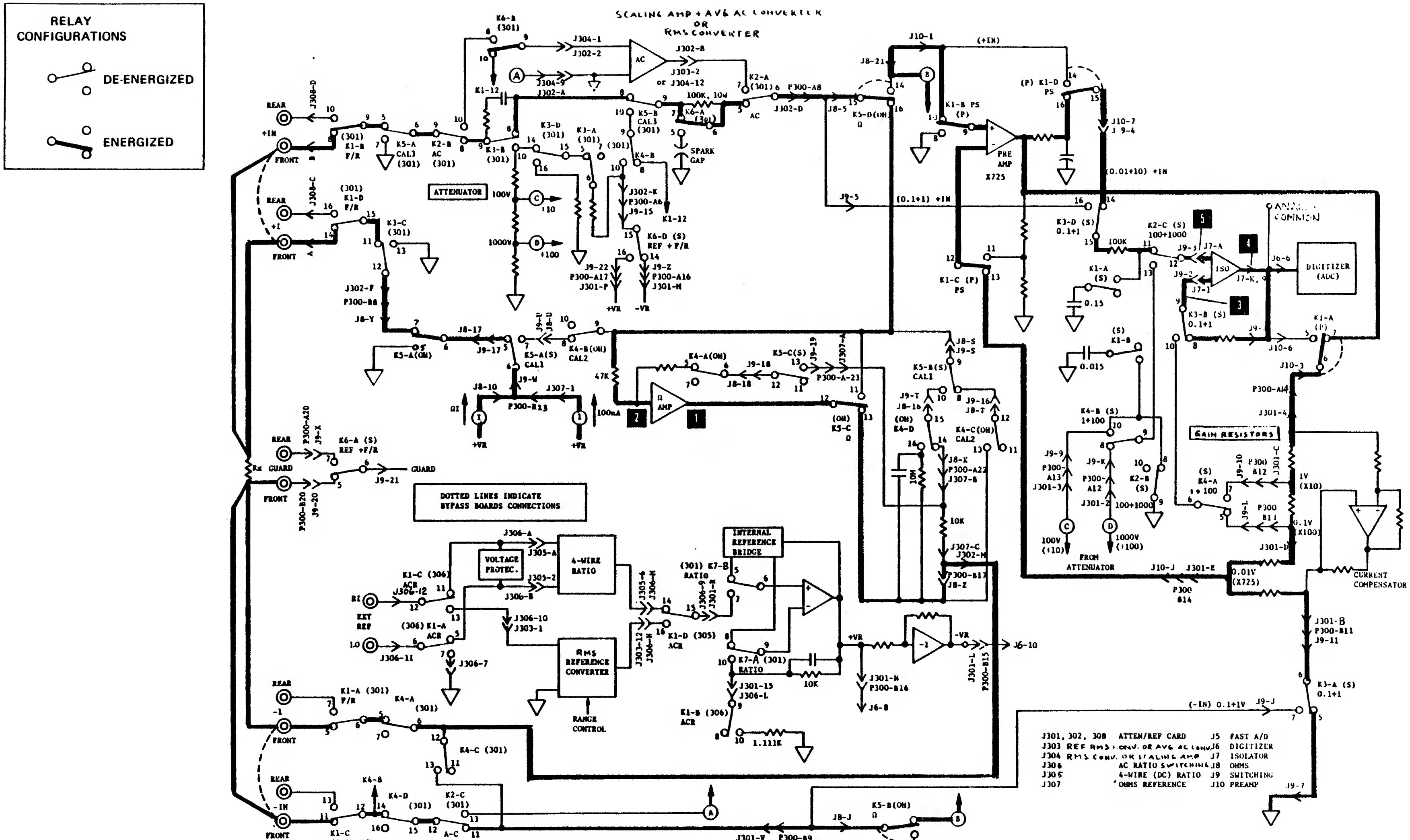


Figure 6.10 - 1 Ohm Range Singlethread Troubleshooting Diagram

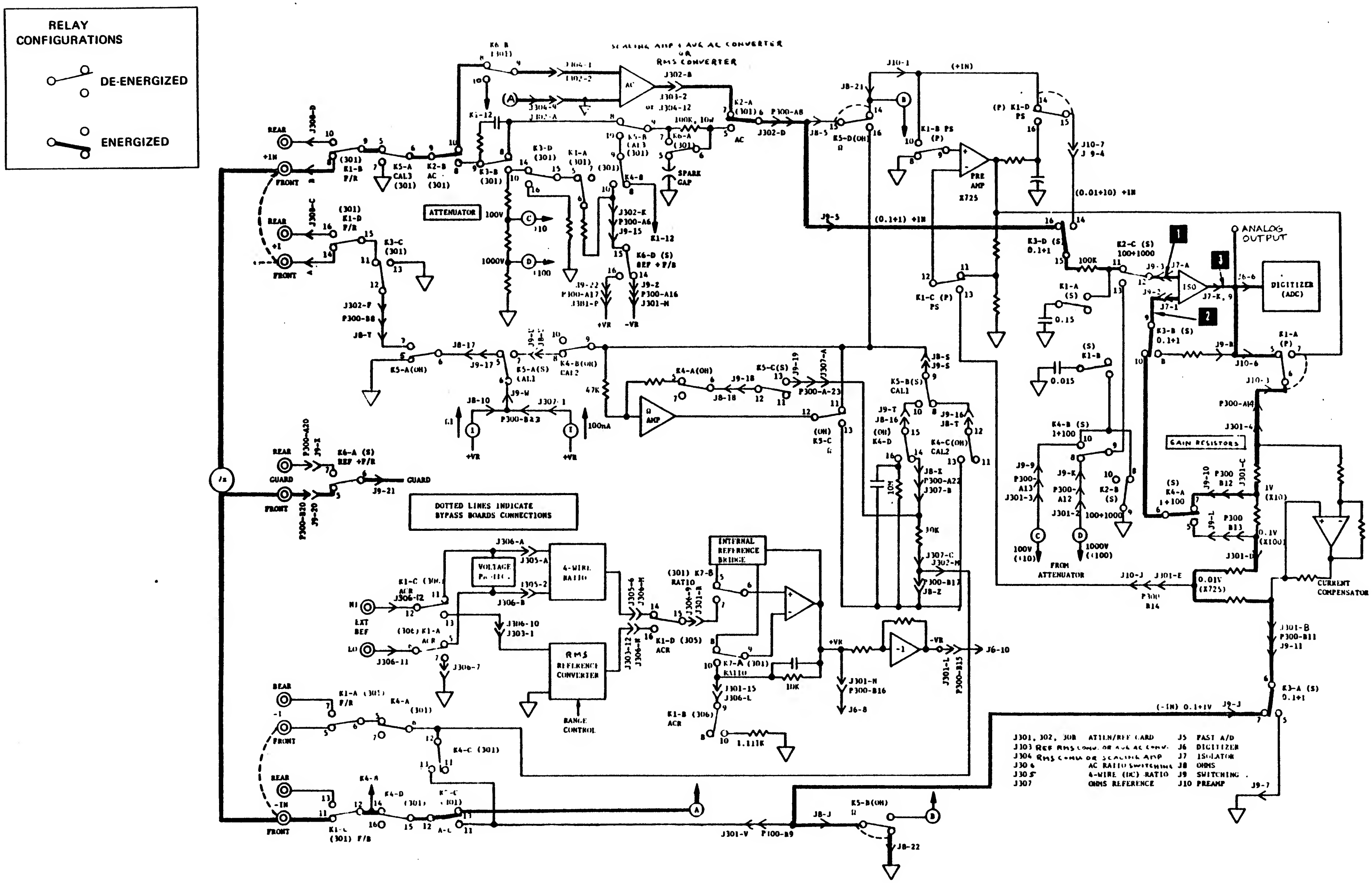


Figure 6.11 - AC Volts Singlethread Troubleshooting Diagram

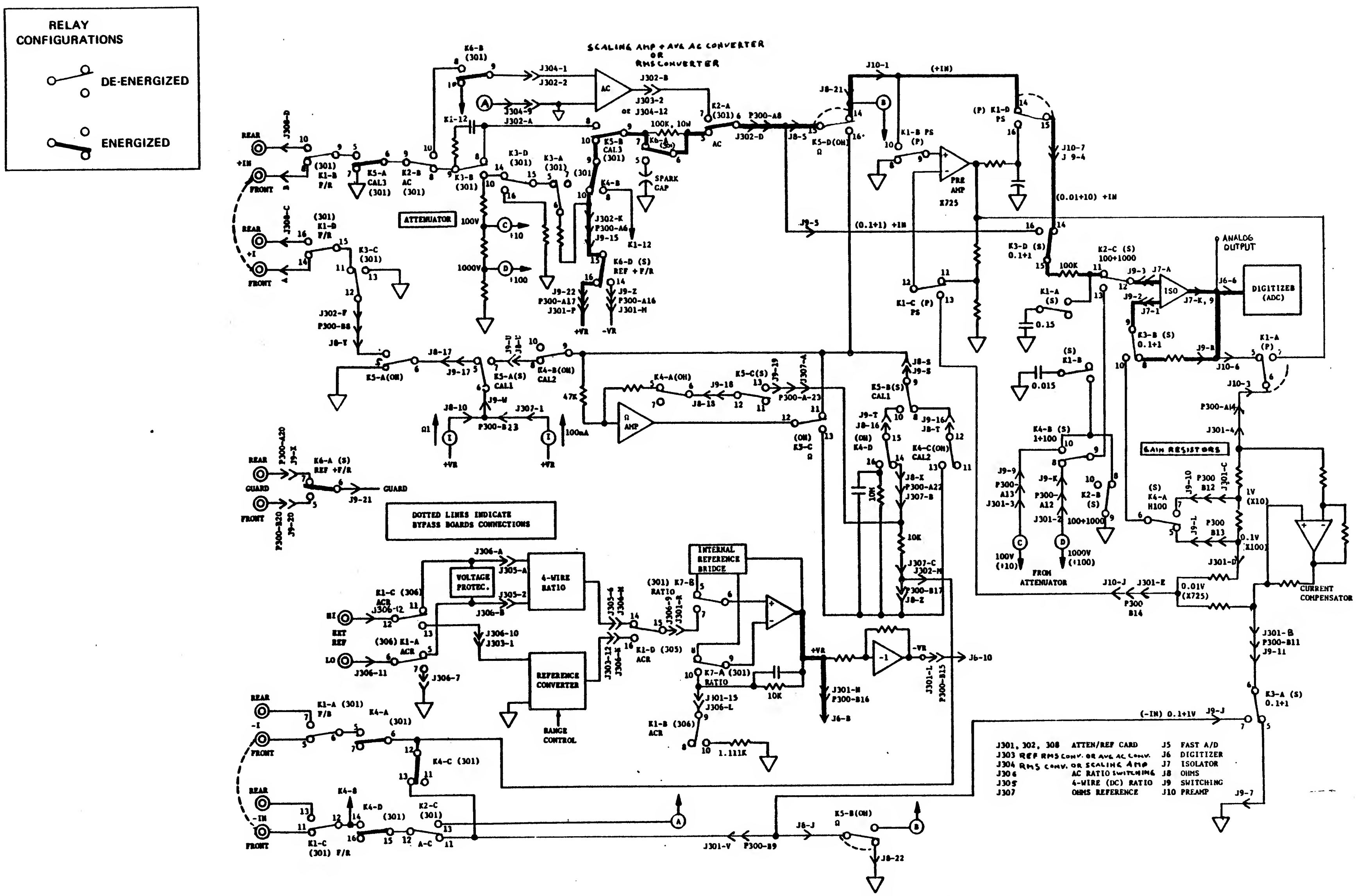


Figure 6.12 - Auto-Cal Configuration - DC CAL 1

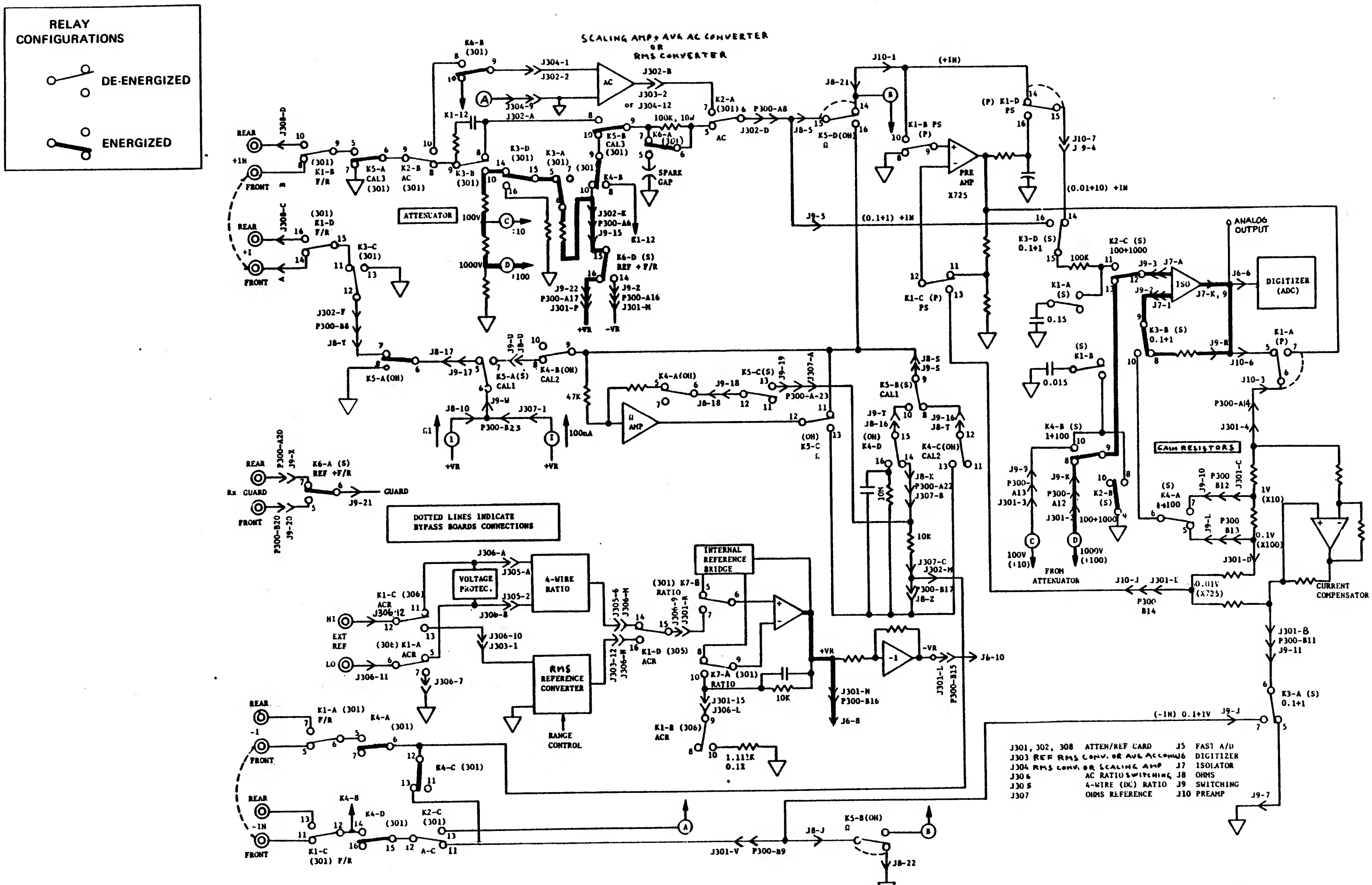


Figure 6.13 - Auto-Cal Configuration - DC CAL 2

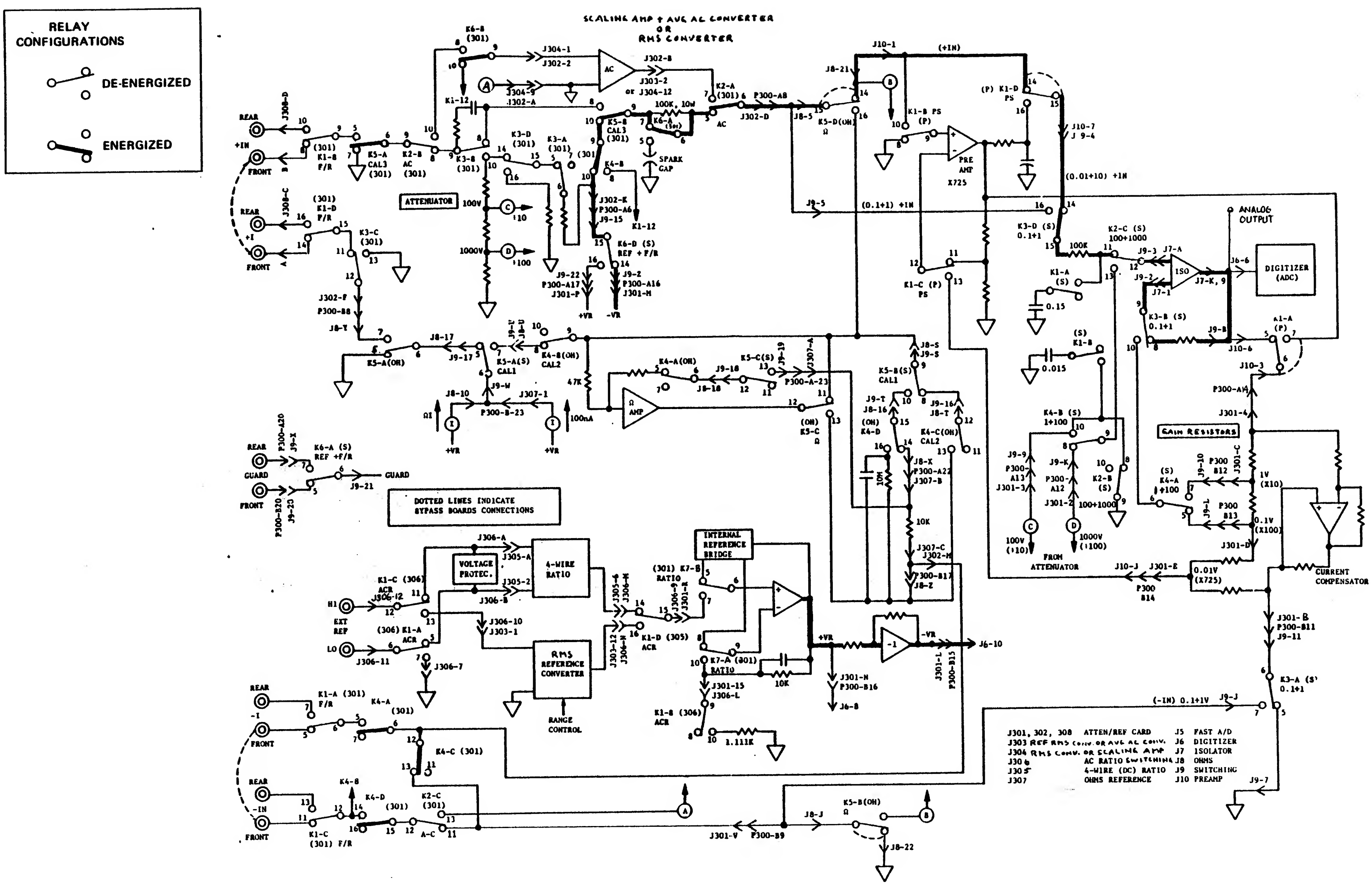


Figure 6.14 - Auto-Cal Configuration - DC CAL 3

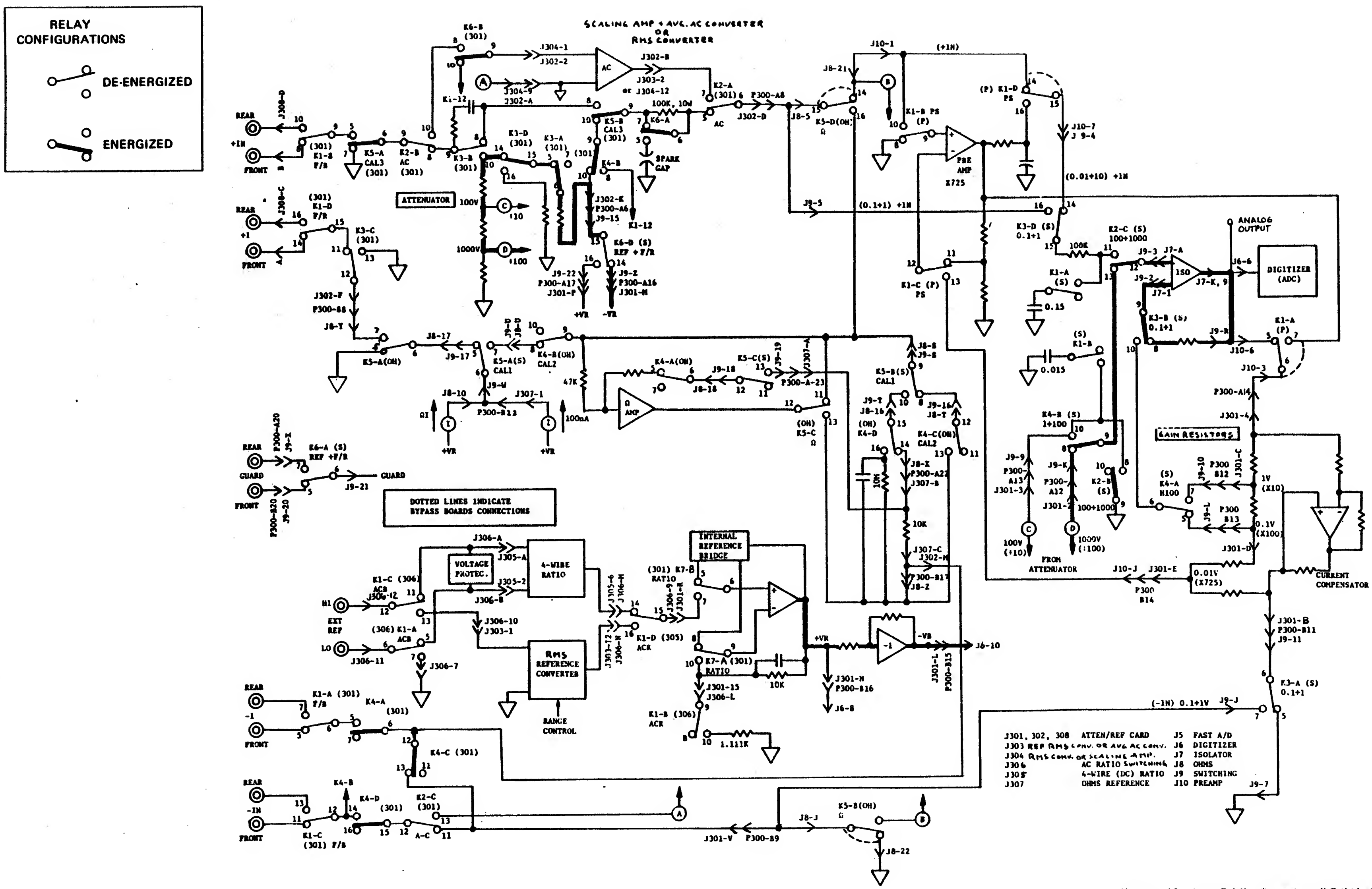
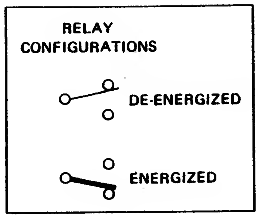


Figure 6.15 - Auto-Cal Configuration - DC CAL 4



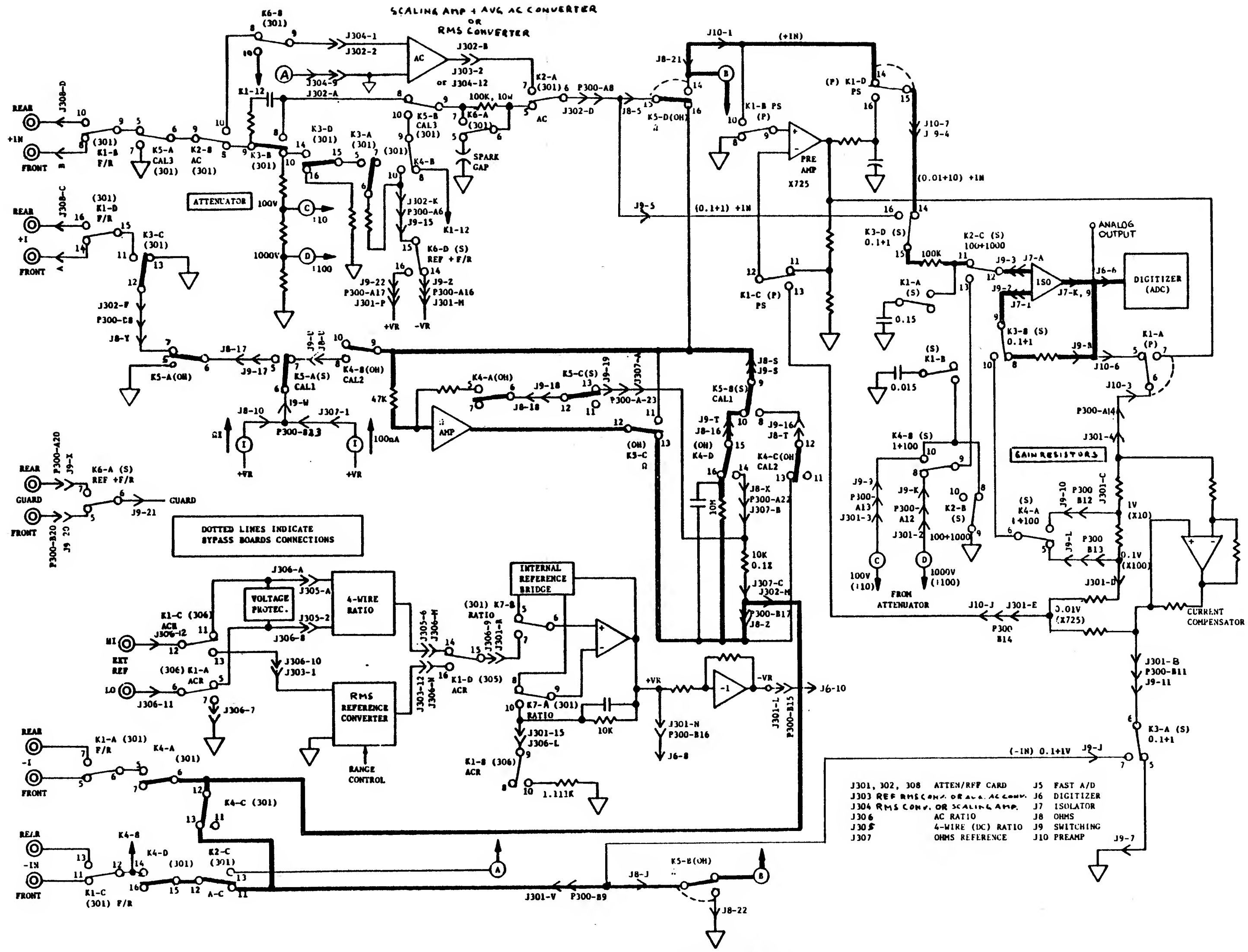


Figure 6.16 - Auto-Cal Configuration - OHMS CAL 4

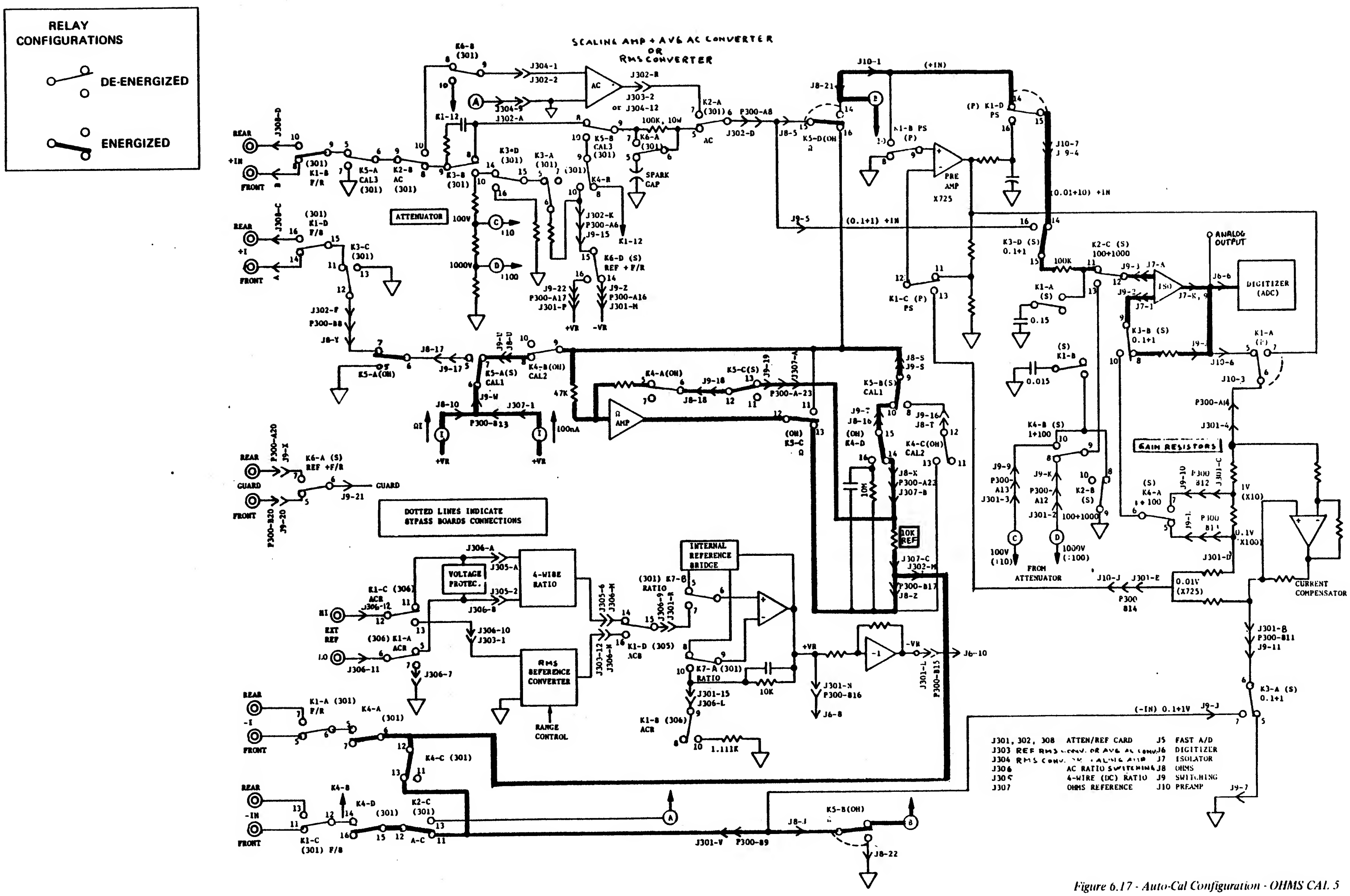


Figure 6.17 - Auto-Cal Configuration - OHMS CAL 5

Table 6.11 - Display/Keyboard Subassembly Performance Test

Input and Control Setting	Signal Nomenclature	Reference Designation	Test Point	Illustration Reference	Performance Standard
Function: DC Range: Auto		CR17	1	Figure 6.18	DC annunciator lit
Function: AC Range: Auto		CR18	2	Figure 6.18	AC annunciator lit
Function: Ohms Range: 10-100		CR19	3	Figure 6.18	Ohms annunciator lit
Function: Ohms Range: 1K-100K Input Terminals: +IN/+I terminals connected with a copper jumper to –IN/–I		LED1 through LED9	4	Figure 6.18	Display LED should indicate 0 ohms

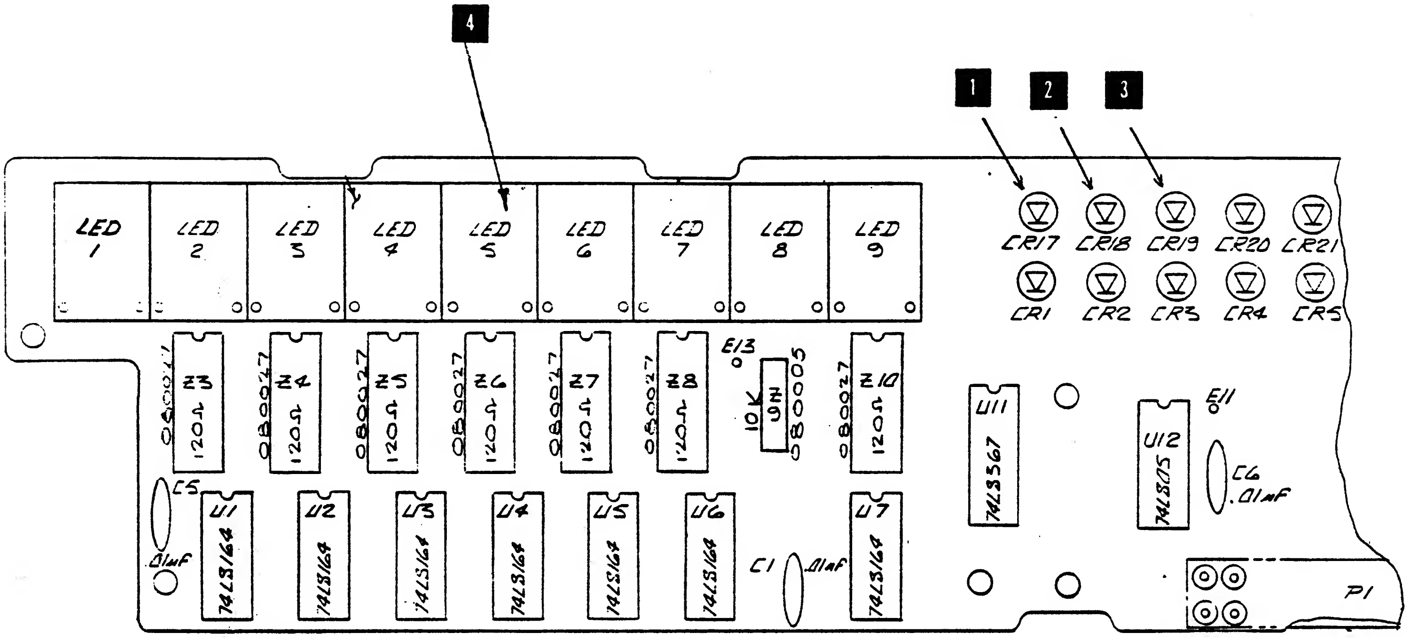


Figure 6.18 - Display/Keyboard Component Location Diagram

Table 6.12 - GPIB IEEE Subassembly Performance Test

Input and Control Setting	Signal Nomenclature	Reference Designation	Test Point	Illustration Reference	Performance Standard
REQUIREMENT The Controller makes device a listener	This performance test assumes that the DMM is operating with an HP 9825 calculator/controller Program: wrt 700" "; CLI7. All waveform measurements (except 2 and 3) are synced to ATN negative edge.				
	ATN	U25-12	1	Figure 6.19	TTL High Level
	NRFD	U29-4	A	Figure 6.19	Waveform 4
	DAV	U29-3	B	Figure 6.19	Waveform 5
	NDAC	U29-2	C	Figure 6.19	Waveform 6
	LIS Flip-Flop	U7-9	D	Figure 6.19	Waveform 1
	Address Compare	U18-8	E	Figure 6.19	Waveform 2
	Qualifier Inverter	U25-8	F	Figure 6.19	Waveform 3

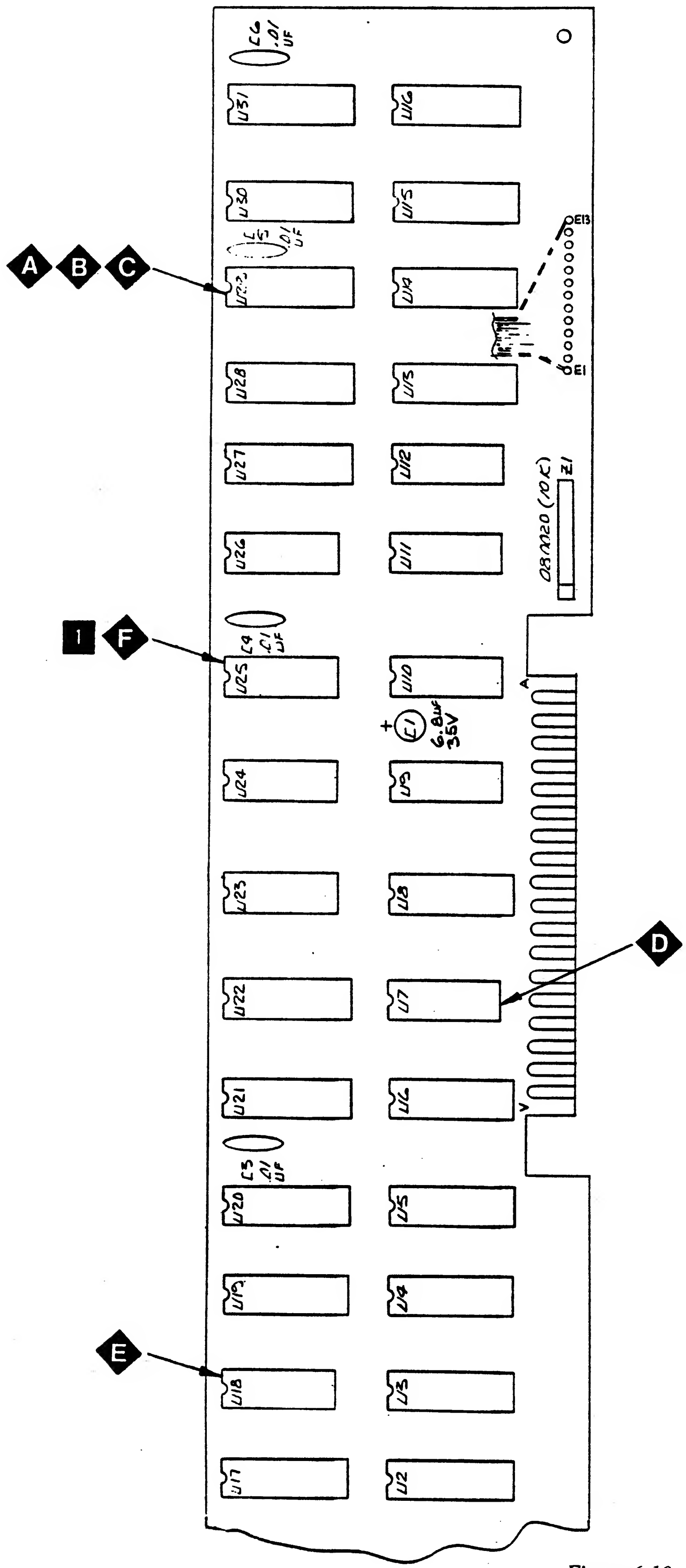
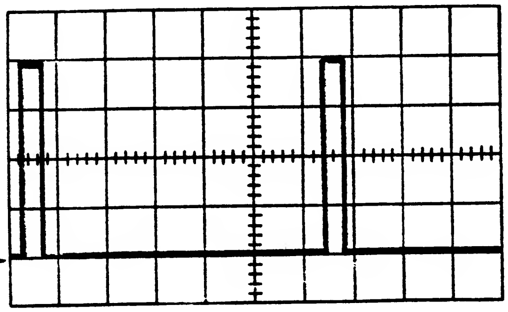


Figure 6.19 - GPIB Component Location Diagram

WAVEFORMS FOR TABLE 6.12

1
(NO.)



1V
(V/DIV)

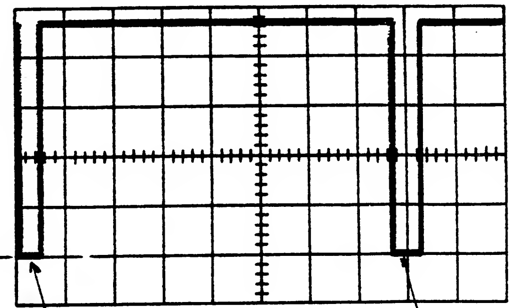
0V

50μS

.1mS
(S/DIV)

2
(NO.)

NO SYNC



1V
(V/DIV)

OV

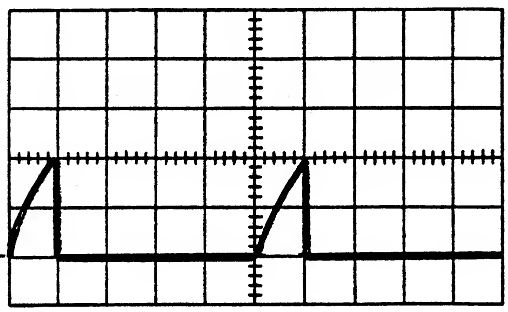
4μSEC

10μ S
(S/DIV)

4μS

3
(NO.)

NO SYNC

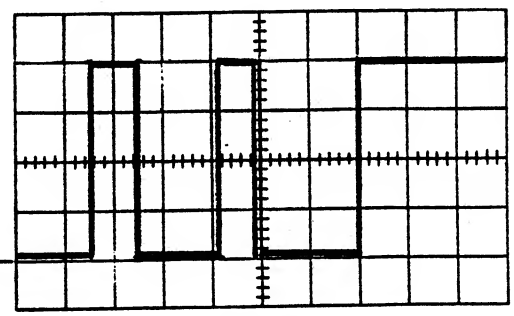


1V
(V/DIV)

OV

.2μS
(S/DIV)

4
(NO.)

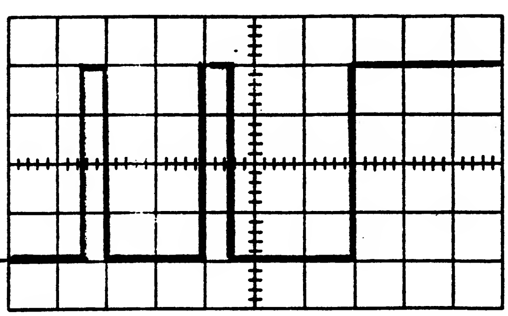


1V
(V/DIV)

0V

20μS
(S/DIV)

5
(NO.)

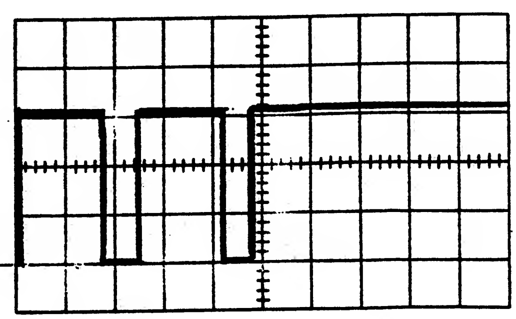


1V
(V/DIV)

OV

20μS
(S/DIV)

6
(NO.)



1V
(V/DIV)

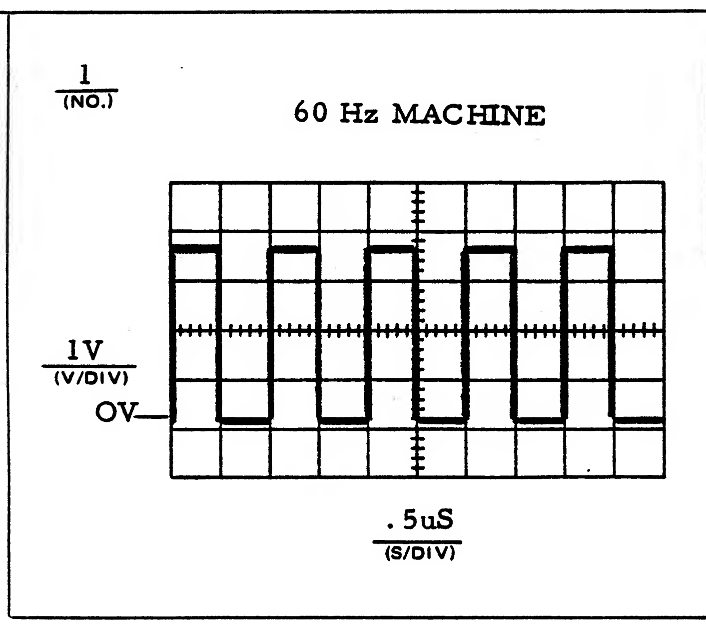
OV

20μS
(S/DIV)

Table 6.13 - Computer 1 Subassembly Performance Test

Input and Control Setting	Signal Nomenclature	Reference Designation	Test Point	Illustration Reference	Performance Standard
Function: DC Range: Auto Input Terminals: +10V DC	Ø2	U2-8	A	Figure 6.20	Waveform 1
Cycle Power Switch	Display should read "6000"				
Press and Hold ☐ DC	After five seconds the "6000" on the display should be replaced by "7"				
In a "make before break" fashion, press the keys in the order shown in the chart and verify that the appropriate number is displayed. Do not press the "Shift" key.	(see chart below)				

☐ Key	Number Displayed	☐ Key	Number Displayed	☐ Key	Number Displayed	☐ Key	Number Displayed
DC	7	STORE	15	9	22	3	10
AC	4	RECALL	12	8	21	2	9
Ω	3	# DIGITS	19	7	18	1	2
FILTER	0	C/S	16	6	17	0	1
DN	11	EXP	23	5	14	•	6
UP	8	CE	20	4	13		



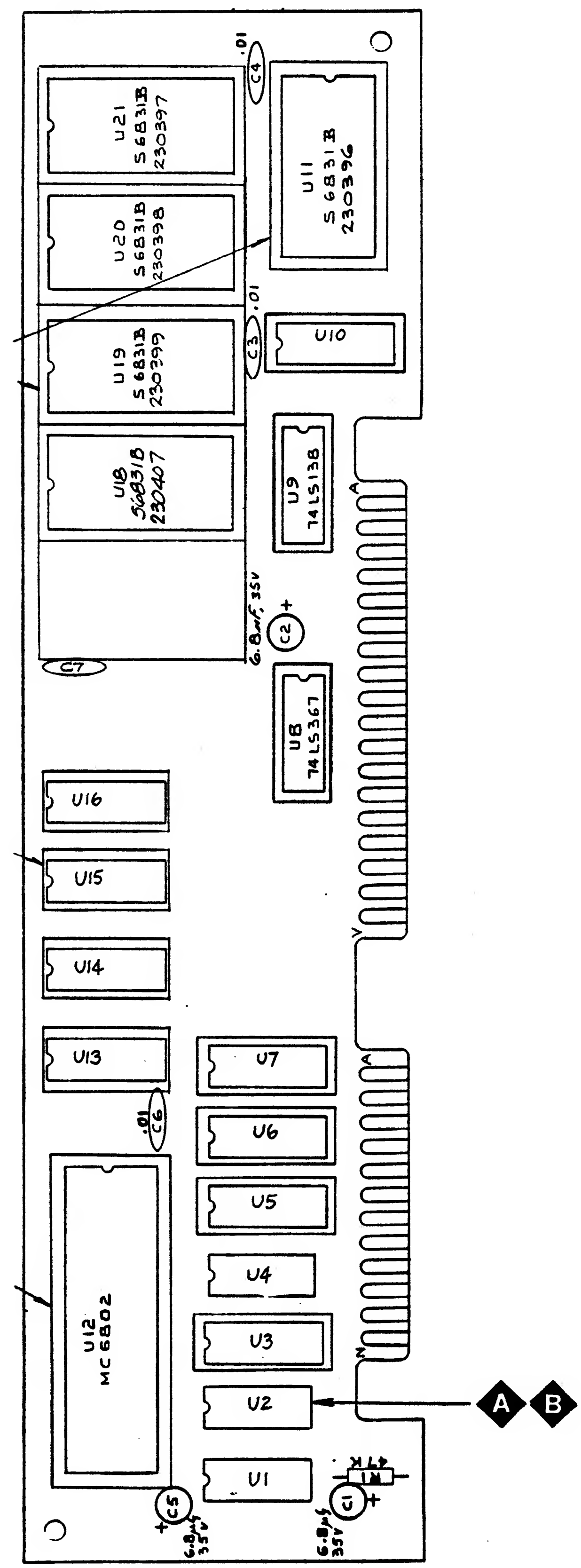


Figure 6.20 - Computer I - Component Location Diagram

Table 6.14 - Control Logic Subassembly Performance Test

Input and Control Setting	Signal Nomenclature	Reference Designation	Test Point	Illustration Reference	Performance Standard
Function: DC Range: Auto Input Terminals: +10V DC	Waveforms 3, 5 and 6 are synced to the negative edge of the signal at U9-6.				
	Master clock output	U17-3	A	Figure 6.21	Waveform 1
	4F0 output	U21-5	B	Figure 6.21	Waveform 2
	Clock Sync output	U18-3	C	Figure 6.21	Waveform 3
	Reset timer output	U9-8	D	Figure 6.21	Waveform 4
	Signal integrate	U7-9	E	Figure 6.21	Waveform 5
	Zero Crossing enable	U19-8	F	Figure 6.21	Waveform 6

WAVEFORMS FOR TABLE 6.14

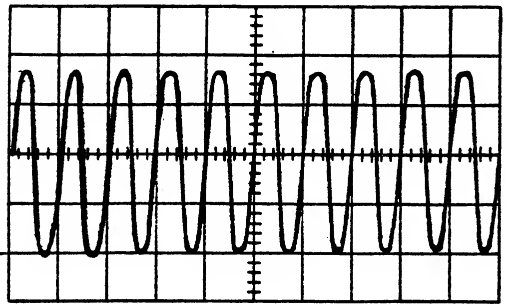
1 (NO.)

INTERNAL SYNC + EDGE

SINEWAVE 41.66 nS (60 Hz)

1V (V/DIV)

OV



50nS (S/DIV)

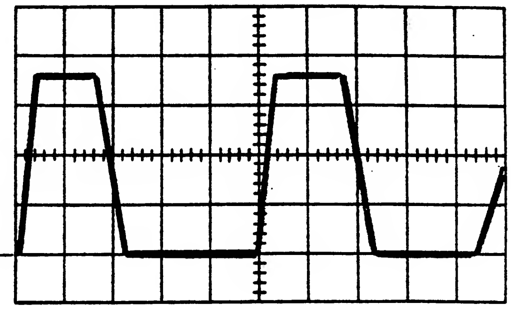
U17-3

2 (NO.)

INTERNAL SYNC + EDGE

1V (V/DIV)

OV



50nS (S/DIV)

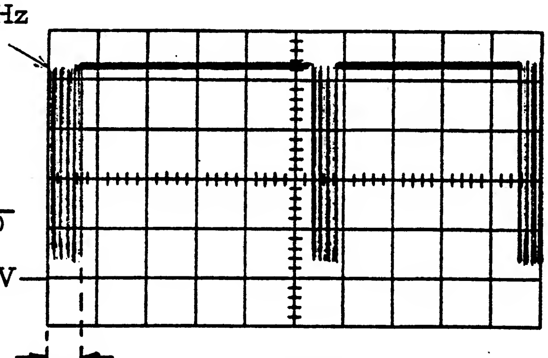
U21-5

3 (NO.)

24MHz

1V (V/DIV)

OV



16.66 ms

50mS (S/DIV)

U18-3

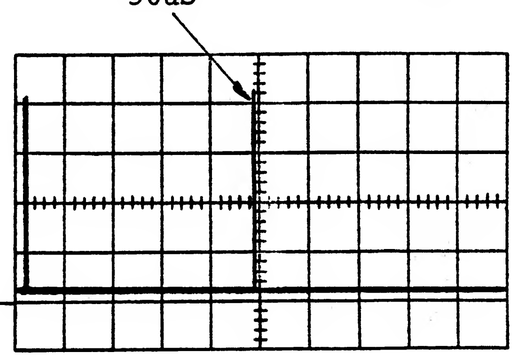
4 (NO.)

INTERNAL SYNC + EDGE

50uS

1V (V/DIV)

OV



50mS (S/DIV)

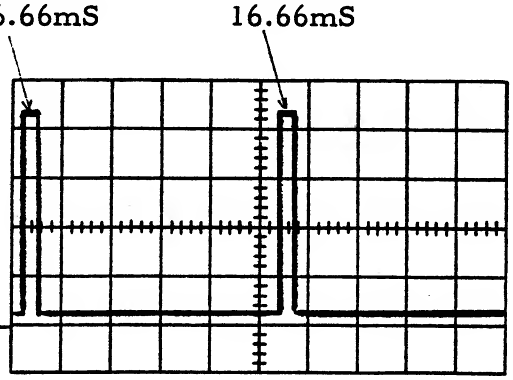
U9-8

5 (NO.)

16.66mS 16.66mS

1V (V/DIV)

OV



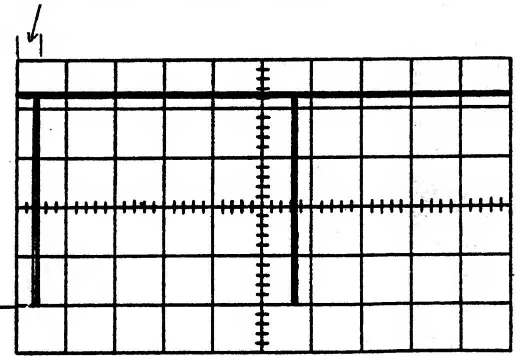
50mS (S/DIV)

U7-9

6 (NO.)

16.66mS FROM SYNC

1V (V/DIV)



50mS (S/DIV)

U19-8

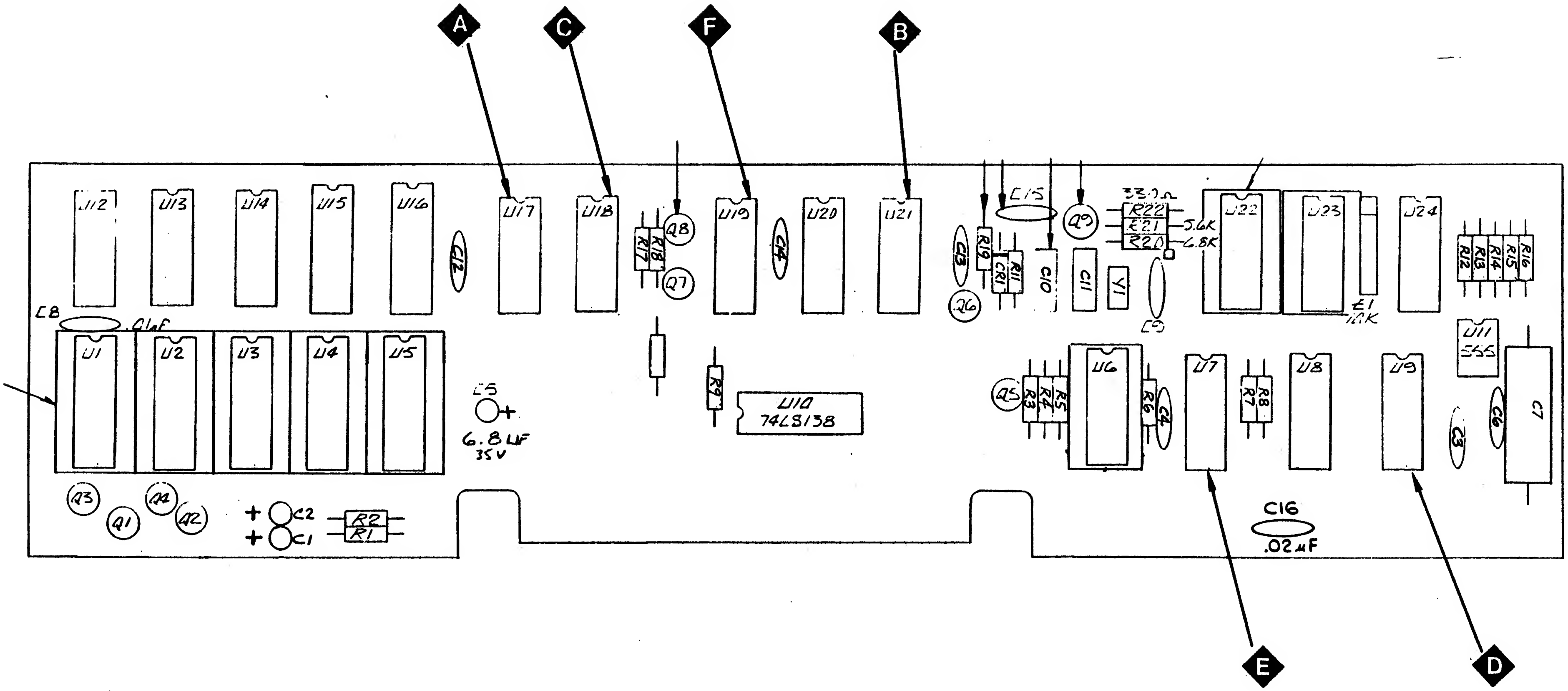
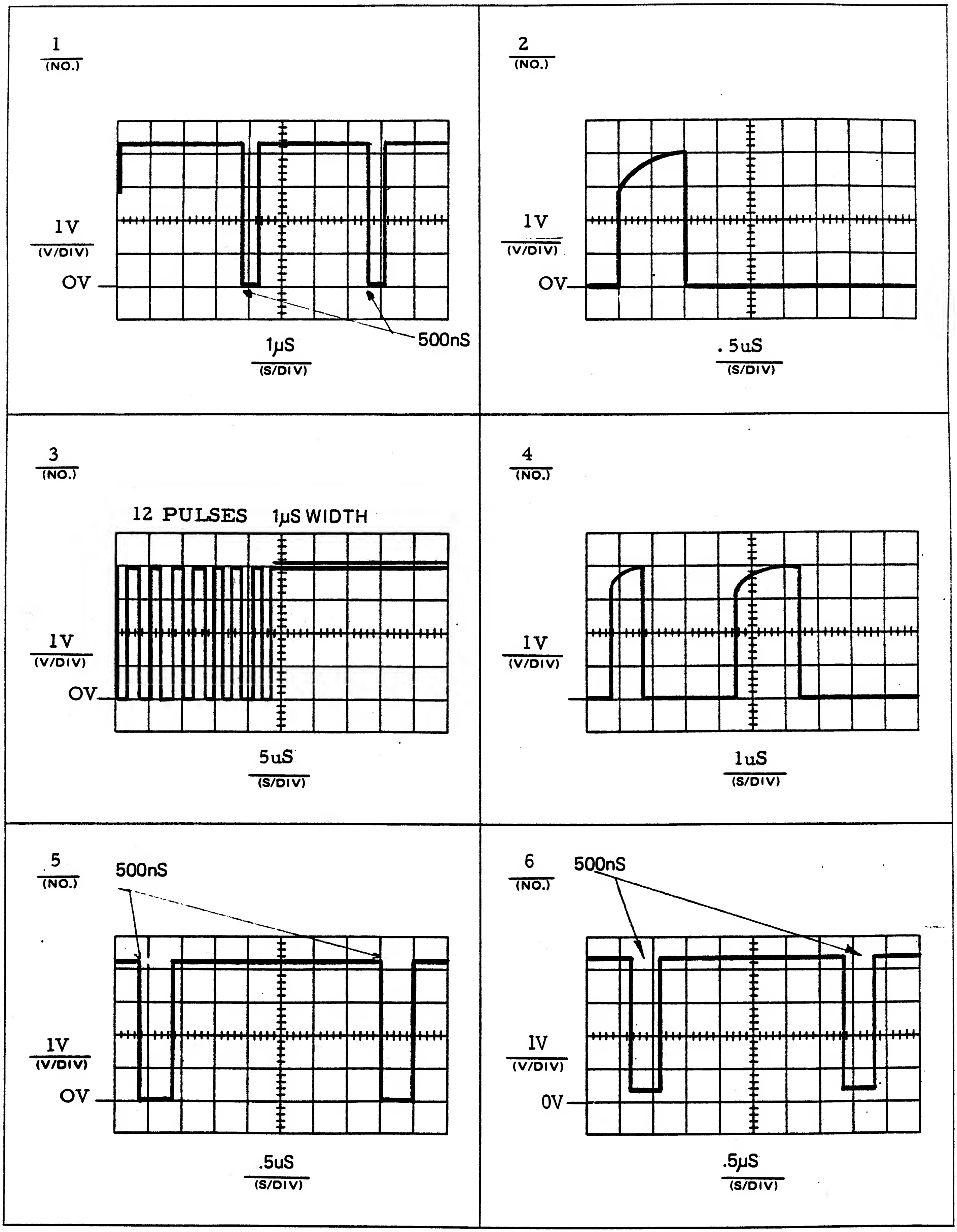


Figure 6.21 - Control Logic
Component Location Diagram

Table 6.15 - Fast Waveform Digitizer Subassembly Performance Test

Input and Control Setting	Signal Nomenclature	Reference Designation	Test Point	Illustration Reference	Performance Standard
Function: DC Range: Auto Input Terminals: +10V DC (1777 octal on display)	All waveforms are synced to the positive edge of the MPU trigger signal (U7-5).				
	Serial/parallel output Reg. reset	U8-6	A	Figure 6.22	Waveform 1
	A/D trigger	U2-5	B	Figure 6.22	Waveform 2 Note: Ground Scope at U2-8
	Serial/parallel output Reg. clock	U8-3	C	Figure 6.22	Waveform 3
	A/D data	U15-3	D	Figure 6.22	Waveform 4
	MPU data bus output enable	J1-A	E	Figure 6.22	Waveform 5
	MPU data bus output enable	J1-1	F	Figure 6.22	Waveform 6

WAVEFORMS FOR TABLE 6.15



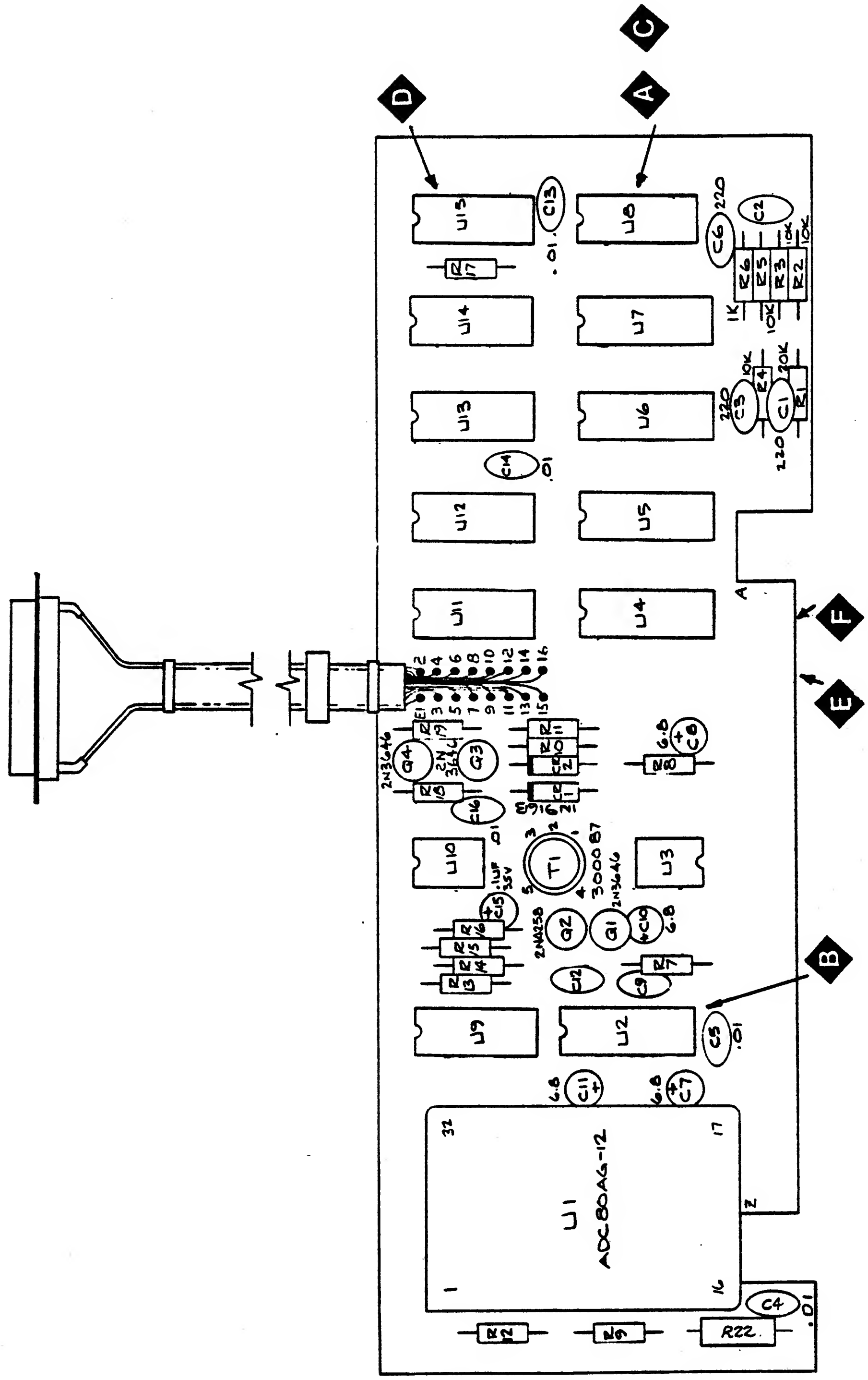


Figure 6.22 - Fast Waveform Digitizer Component Location Diagram

Table 6.16 - Digitizer Subassembly Performance Test

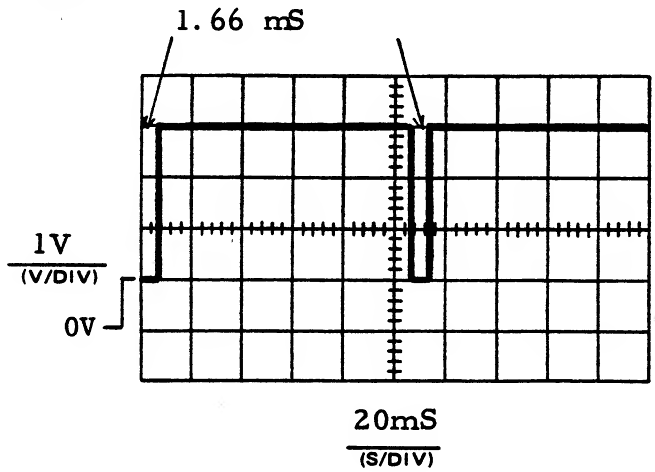
Input and Control Setting	Signal Nomenclature	Reference Designation	Test Point	Illustration Reference	Performance Standard
Function: DC Range: Auto Input Terminals: +10V DC Select 4-1/2 Digit Mode (#DIG, 4)	All waveforms are synced to the negative edge of the waveform at TP2.				
	Signal integrate	TP3	A	Figure 6.23	Waveform 1
	Integrator input	TP4	B	Figure 6.23	Waveform 2
	Integrator output	TP5	C	Figure 6.23	Waveform 3
	Null detector output	TP1	D	Figure 6.23	Waveform 4
	Reset FET drive signal	TP2	E	Figure 6.23	Waveform 5
Function: DC Range: Auto Input Terminals: +10V DC Select 5-1/2 Digit Mode (#DIG, 5)	All waveforms are synced to the negative edge of the waveform at TP2.				
	Signal integrate	TP3	A	Figure 6.23	Waveform 6
	Integrator input	TP4	B	Figure 6.23	Waveform 7
	Integrator output	TP5	C	Figure 6.23	Waveform 8
	Null detector output	TP1	D	Figure 6.23	Waveform 9
	Reset FET drive signal	TP2	E	Figure 6.23	Waveform 10

Table 6.16 - Digitizer Subassembly Performance Test (Continued)

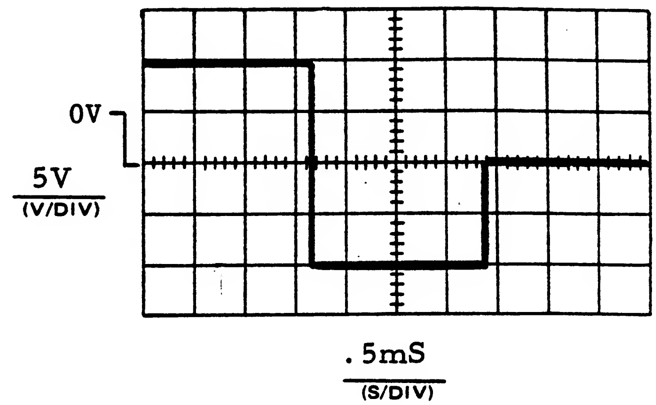
Input and Control Setting	Signal Nomenclature	Reference Designation	Test Point	Illustration Reference	Performance Standard
Function: DC Range: Auto Input Terminals: +10V DC Select 6-1/2 Digit Mode (#DIG, 6)	All waveforms are synced to the negative edge of the waveform at TP2.				
	Signal integrate	TP3	A	Figure 6.23	Waveform 11
	Integrator input	TP4	B	Figure 6.23	Waveform 12
	Integrator output	TP5	C	Figure 6.23	Waveform 13
	Null detector output	TP1	D	Figure 6.23	Waveform 14
	Reset FET drive signal	TP2	E	Figure 6.23	Waveform 15

WAVEFORMS FOR TABLE 6.16

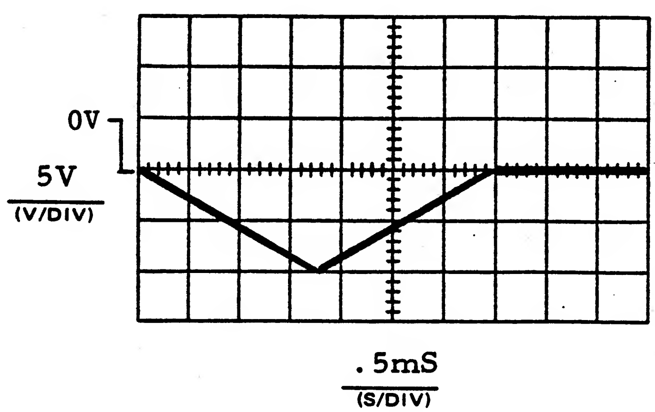
1 (NO.) SIG. INT.



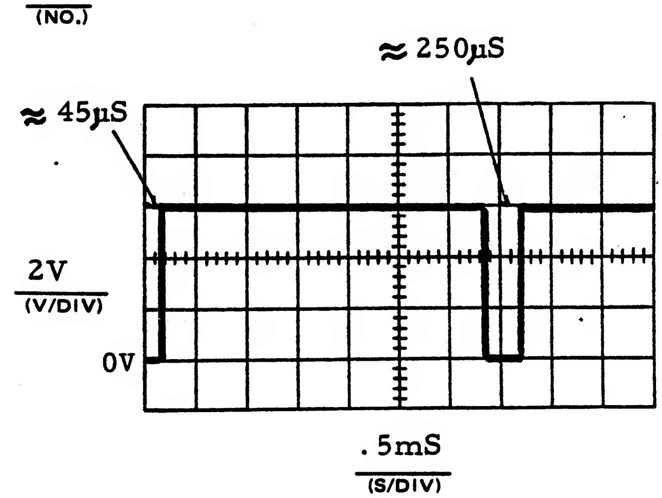
2 (NO.) INT. IN.



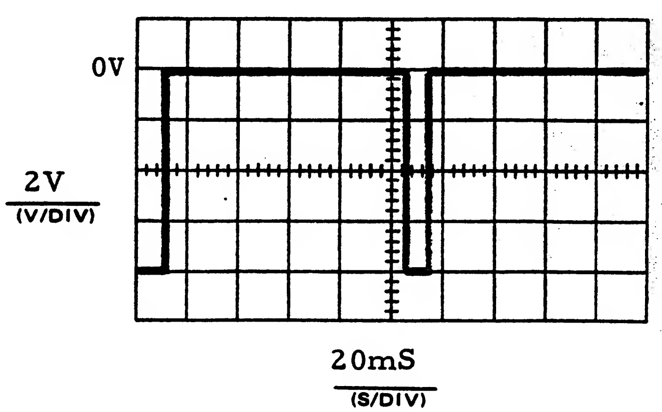
3 (NO.) INT. OUT

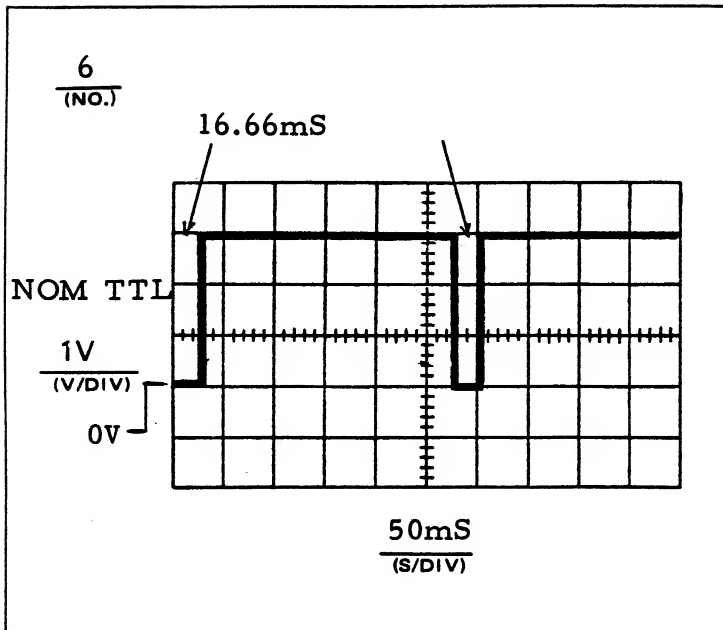


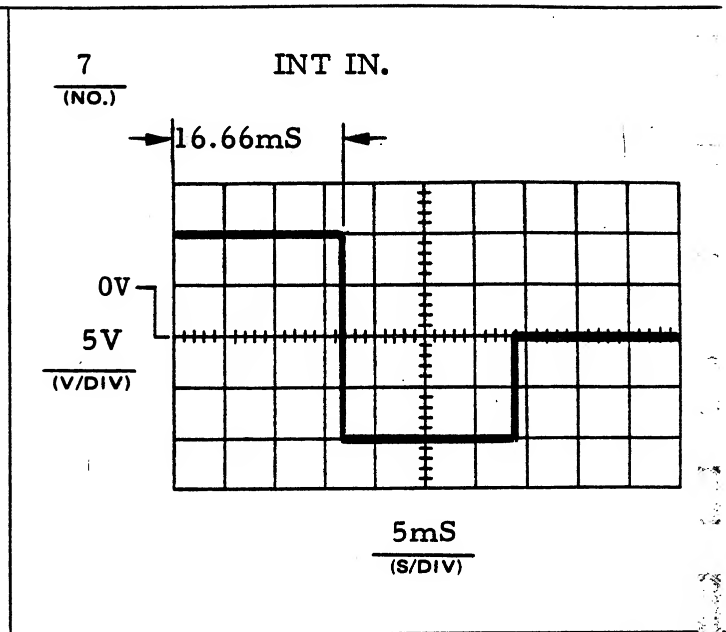
4 (NO.) N.D. OUT

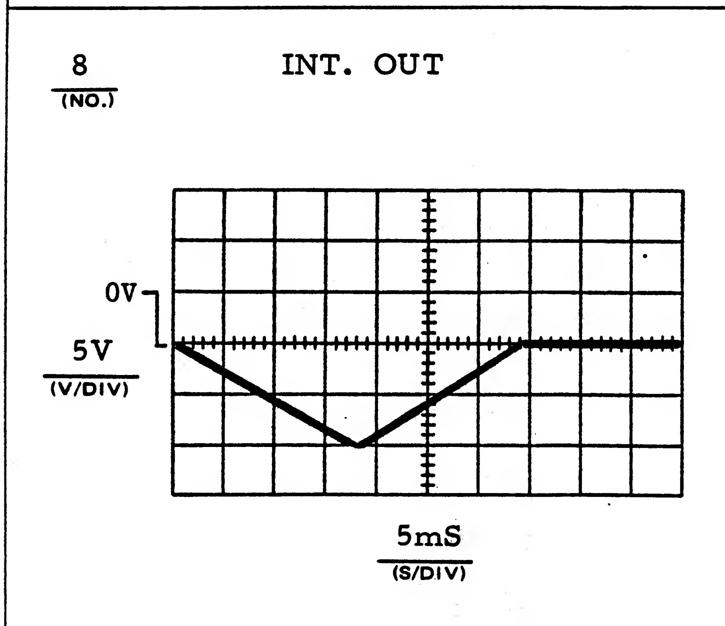


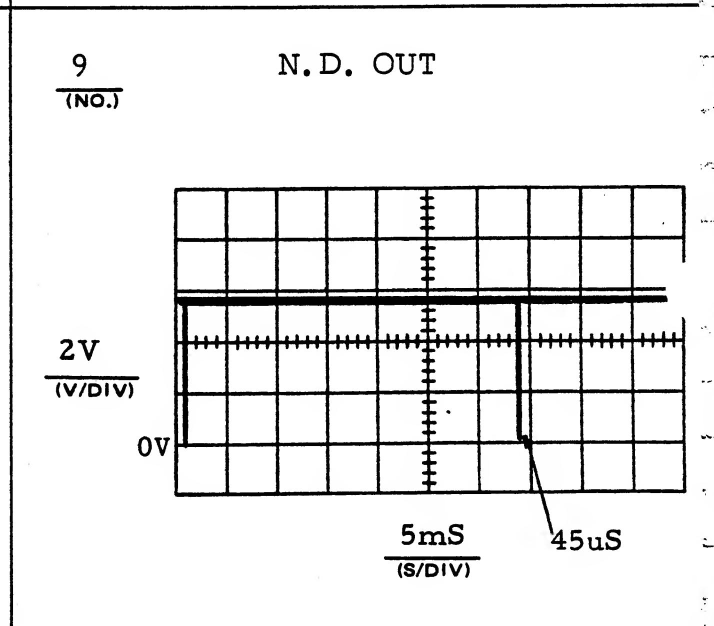
5 (NO.) RESET FET DRIVE

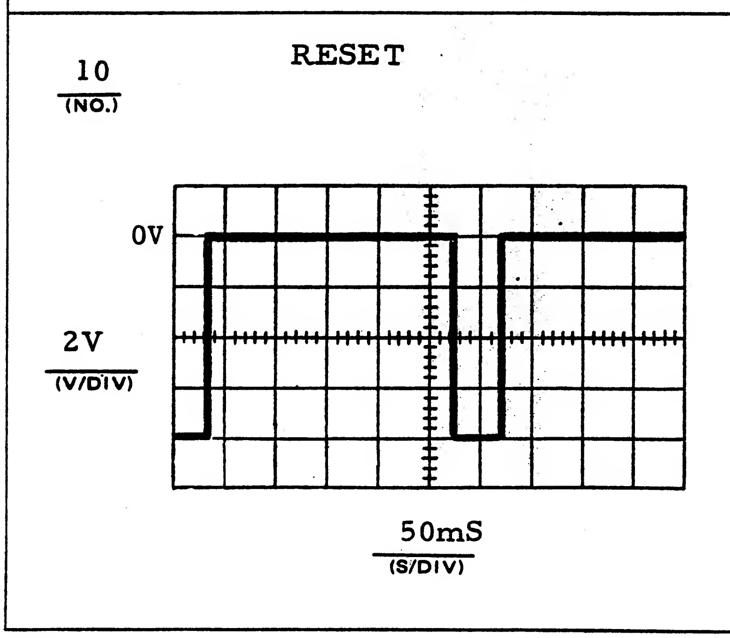



6
(NO.)
16.66mS
NOM TTL
1V
(V/DIV)
0V
50mS
(S/DIV)

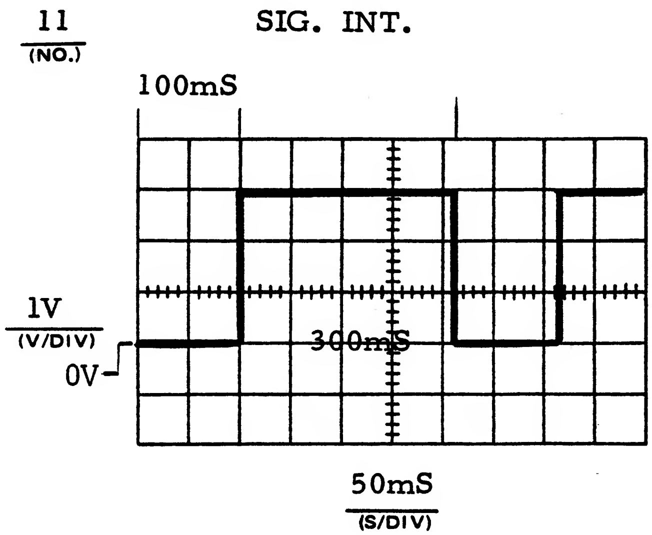

7
(NO.)
INT IN.
16.66mS
0V
5V
(V/DIV)
5mS
(S/DIV)

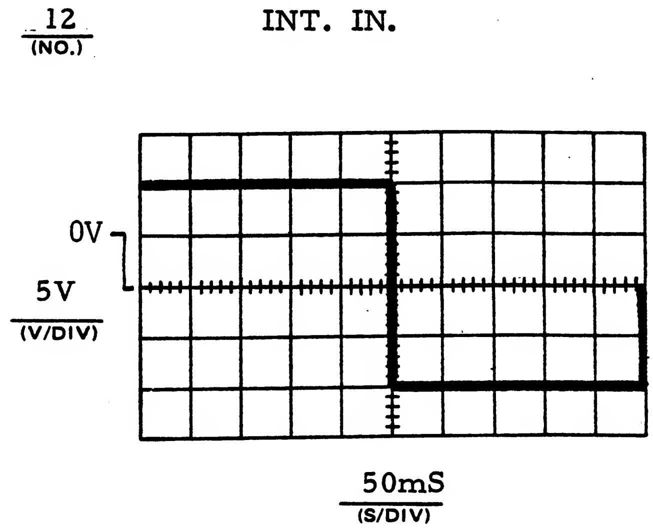

8
(NO.)
INT. OUT
0V
5V
(V/DIV)
5mS
(S/DIV)

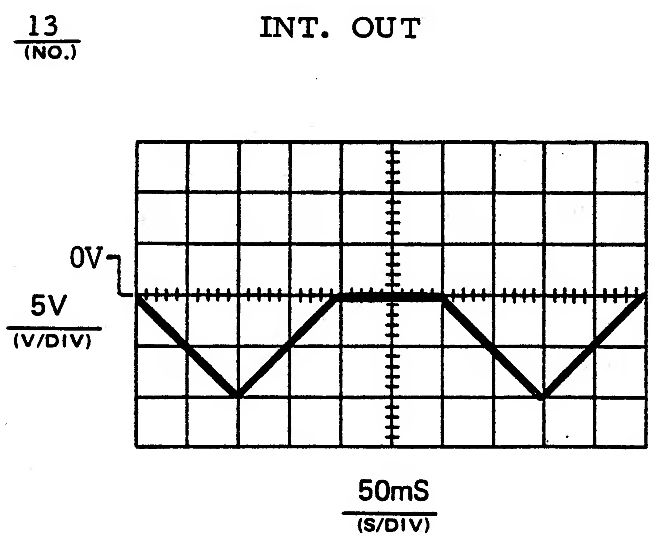

9
(NO.)
N.D. OUT
2V
(V/DIV)
0V
5mS
(S/DIV)
45uS

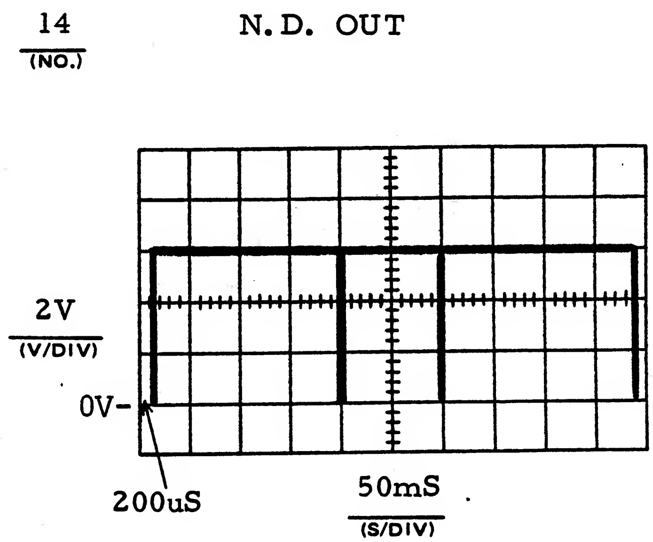

10
(NO.)
RESET
0V
2V
(V/DIV)
50mS
(S/DIV)

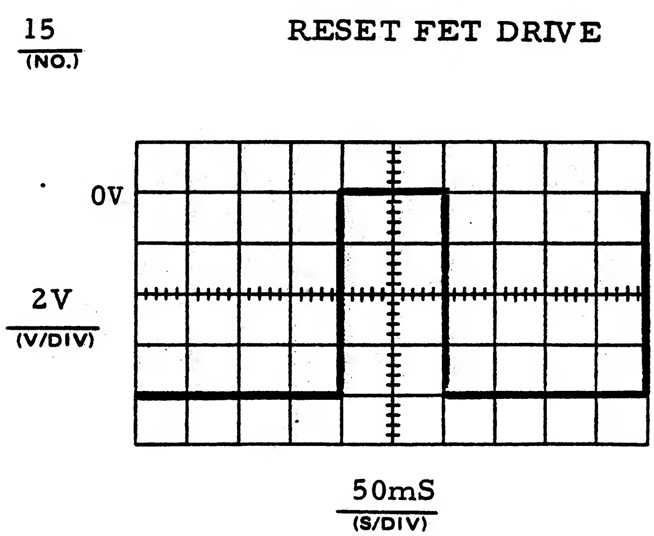
WAVEFORMS FOR TABLE 6.16 (Continued)











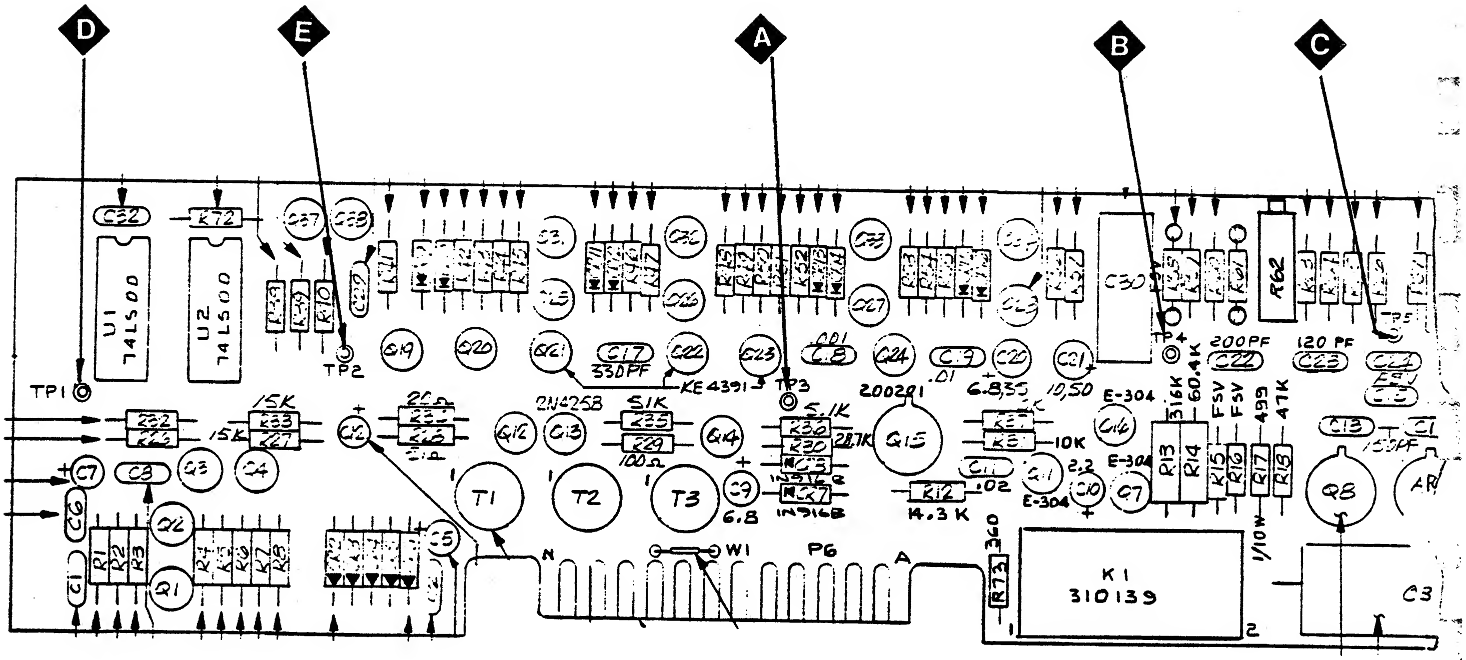


Figure 6.23 - Digitizer Component Location Diagram

Table 6.17 - Isolator Subassembly Performance Test

Input and Control Setting	Signal Nomenclature	Reference Designation	Test Point	Illustration Reference	Performance Standard
Function: DC Range: Auto Input Terminals: +10V DC	All measurements are referenced to Analog Common (Mecca).				
	Gain Stage output	TP3	1	Figure 6.24	+10.0 VDC
	Boot strap Amp output	TP4	2	Figure 6.24	+10.0 VDC
	+10V BS	AR4-7	3	Figure 6.24	+21.0 VDC
	−10V BS	AR4-4	4	Figure 6.24	−1.0 VDC
	Isolator output	TP2	5	Figure 6.24	+10.0 VDC

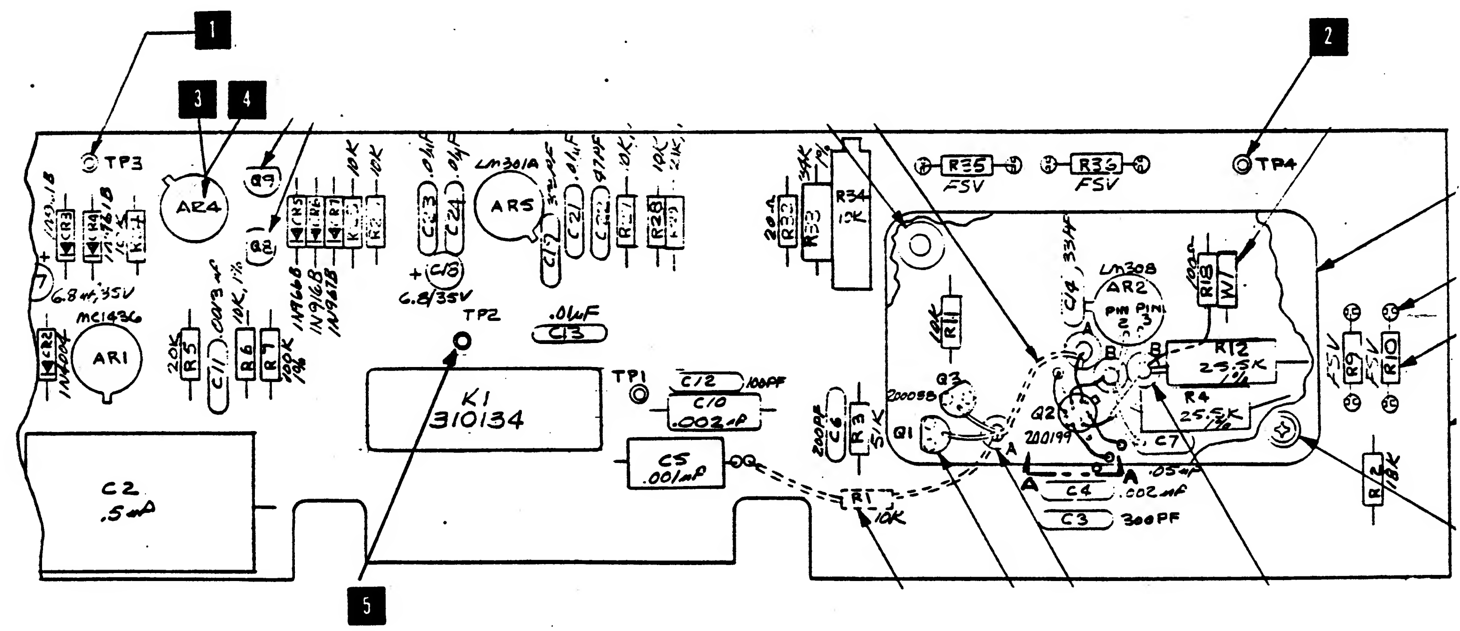


Figure 6.24 - Isolator Component Location Diagram

Table 6.18 - Ohms Subassembly Performance Test

Input and Control Setting	Signal Nomenclature	Reference Designation	Test Point	Illustration Reference	Performance Standard
Function: Ohms	All measurements are referenced to Analog Common (Mecca). All resistance inputs are resistance standards.				
Range: 10Ω Input Terminals: 10Ω	Clamped input	TP1	1	Figure 6.25	+8.0V
	Current generator output	TP3	2	Figure 6.25	+3.7V
	Ohms Amp output	TP4	3	Figure 6.25	–0.1V
Range: 100Ω Input Terminals: 100Ω	Clamped input	TP1	1	Figure 6.25	+8.0V
	Current generator output	TP3	2	Figure 6.25	+3.7V
	Ohms Amp output	TP4	3	Figure 6.25	–1.0V
Range: 1KΩ Input Terminals: 1KΩ	Clamped input	TP1	1	Figure 6.25	+7.999V
	Current generator output	TP3	2	Figure 6.25	+3.0V
	Ohms Amp output	TP4	3	Figure 6.25	–1.0V
Range: 100KΩ Input Terminals: 100KΩ	Clamped input	TP1	1	Figure 6.25	+8.0V
	Current generator output	TP3	2	Figure 6.25	+6.9V
	Ohms Amp output	TP4	3	Figure 6.25	–10.0V

Table 6.18 - Ohms Subassembly Performance Test (Continued)

Input and Control Setting	Signal Nomenclature	Reference Designation	Test Point	Illustration Reference	Performance Standard
Range: 10MΩ Input Terminals: 10MΩ					
	Clamped input	TP1	1	Figure 6.25	+8.0V
	Current generator output	TP3	2	Figure 6.25	+6.9V
	Ohms Amp output	TP4	3	Figure 6.25	−10.0V

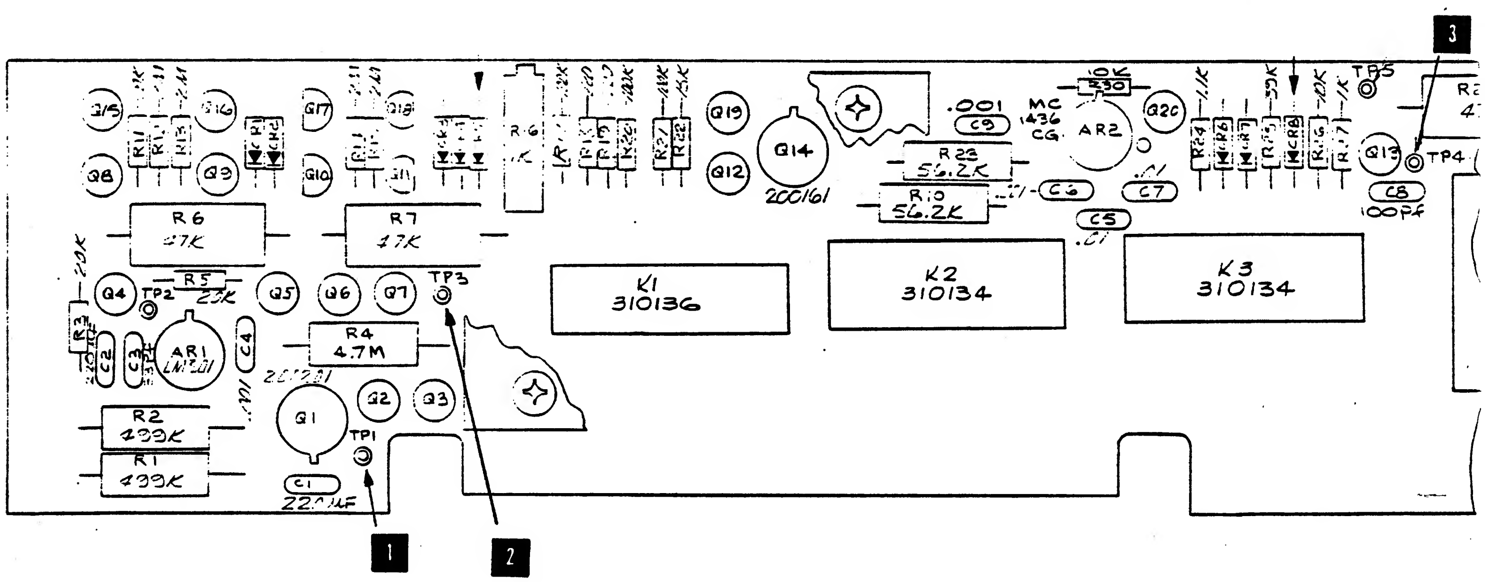


Figure 6.25 - Ohms Component Location Diagram

Table 6.19 - Ohms Reference Subassembly Performance Test

Input and Control Setting	Signal Nomenclature	Reference Designation	Test Point	Illustration Reference	Performance Standard
Function: Ohms	All measurements are referenced to Analog Common (Mecca).				
	Ohms Reference	AR1-6	1	Figure 6.26	+12.0V
		R5/R4	2	Figure 6.26	+8.0V

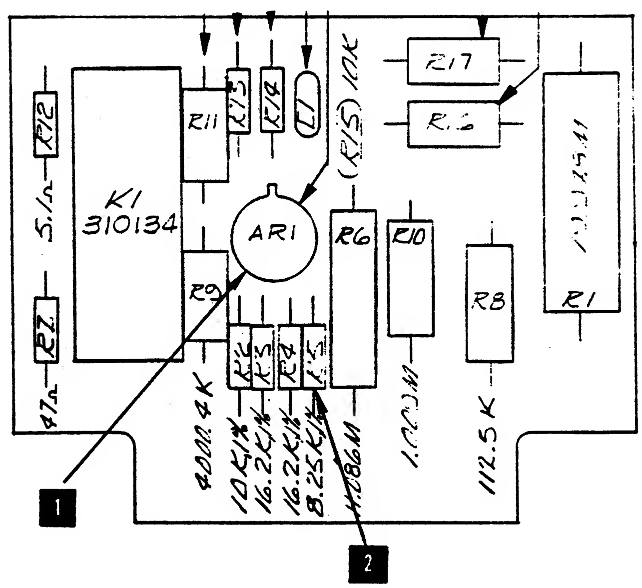


Figure 6.26 - Ohms Reference Component Location Diagram

Table 6.20 - Preamplifier Subassembly Performance Test

Input and Control Setting	Signal Nomenclature	Reference Designation	Test Point	Illustration Reference	Performance Standard
Function: DC **Range: mV** **Input Terminals: +0.01 VDC**	All measurements are referenced to Analog Common (Mecca). Waveforms are synced to the negative edge of the signal at Q8-C.				
	MOD/DEMOD Drive	Q9-C	A	Figure 6.27	Waveform 1
	Input filter output	E15	1	Figure 6.27	
	Feedback	C9/Q1-D	B	Figure 6.27	Waveform 2
	Sync Demod output	C2/R4	C	Figure 6.27	Waveform 3
	Preamplifier output	E3	2	Figure 6.27	+7.2 VDC

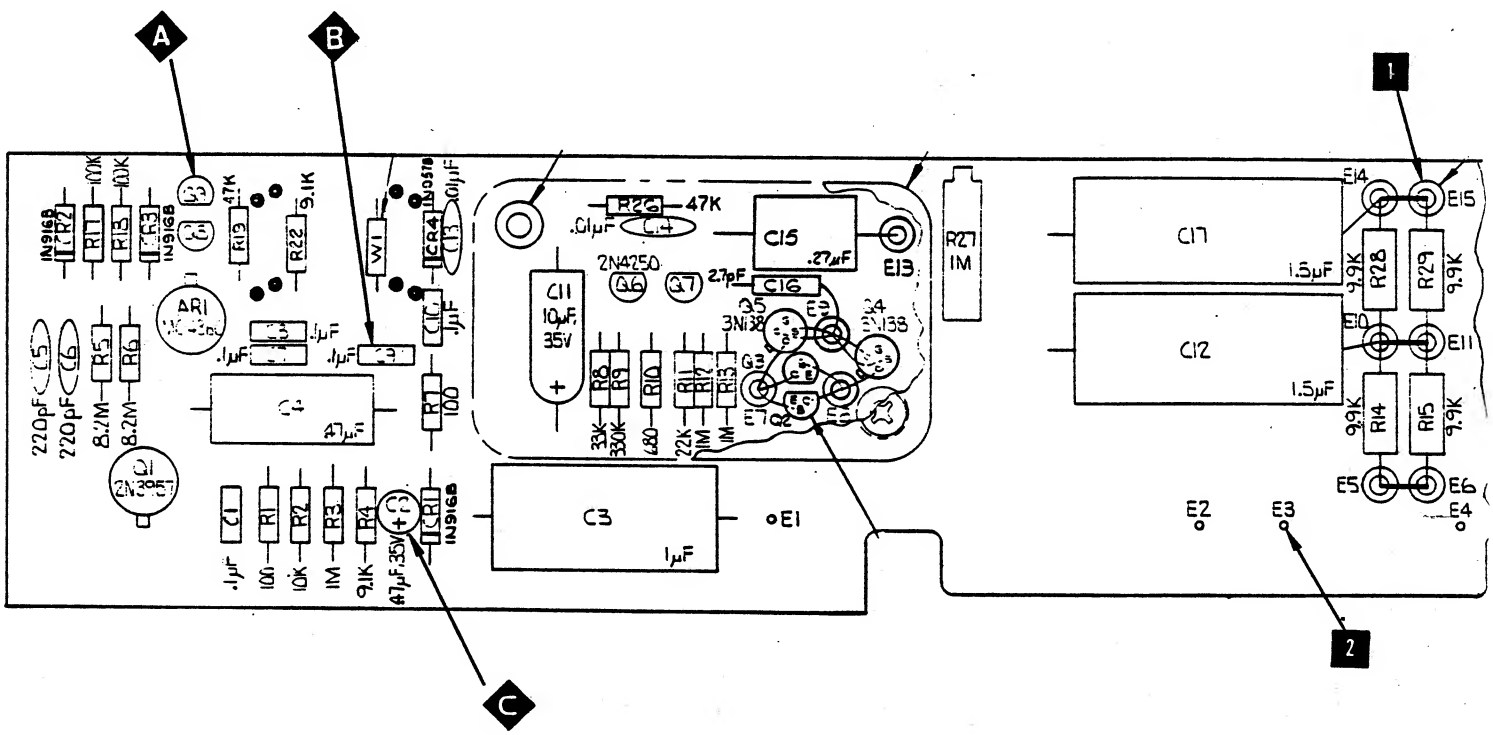
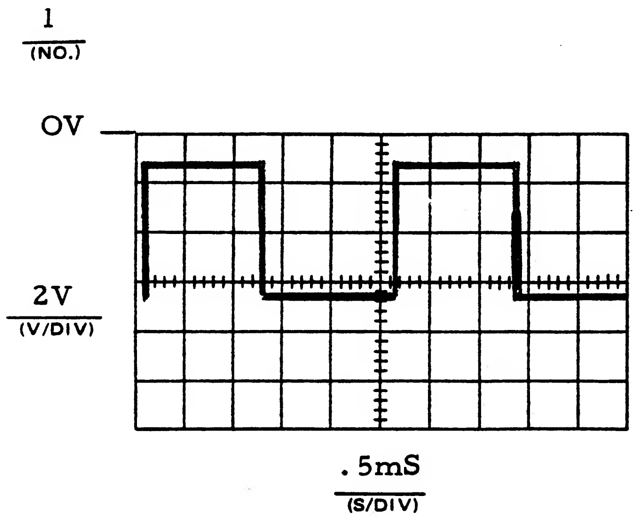
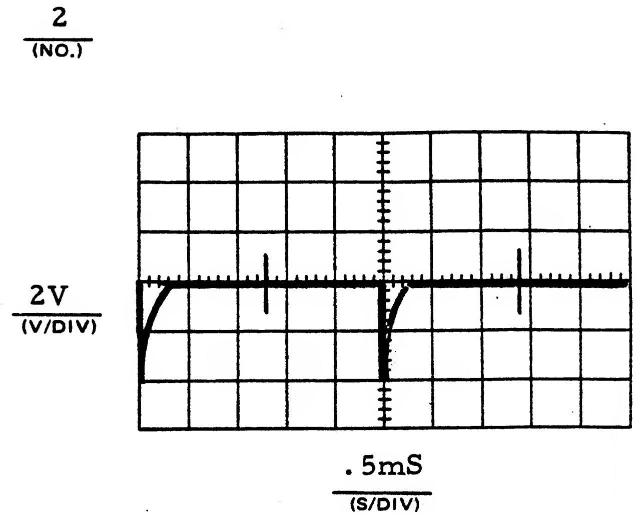


Figure 6.27 - Preamplifier Component Location Diagram

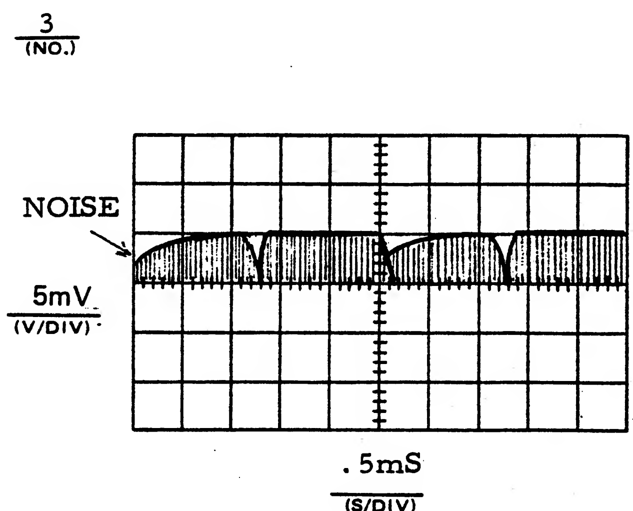
WAVEFORMS FOR TABLE 6.20



Q9-C



C9-Q1-D



C2/R4

Table 6.21 - Attenuator/Reference Subassembly Performance Test

Input and Control Setting	Signal Nomenclature	Reference Designation	Test Point	Illustration Reference	Performance Standard
Press SHIFT and FR/# DIGITS Keys	Measurements 1 and 2 are referenced to Digital Ground.				
	Front/rear relay control	U1-10	1	Figure 6.28	Low logic level when RI indicator on front panel lit. High logic level when RI not lit.
Press AC Key	AC relay control	U1-15	2	Figure 6.28	Low logic level
	Measurements 3 thru 5 are referenced to Analog Common (Mecca).				
	Zener reference	TP1	3	Figure 6.28	+6.2V
	+10V reference output	TP2	4	Figure 6.28	+10.000 VDC
	−10V reference output	Q1-E	5	Figure 6.28	−10.000 VDC

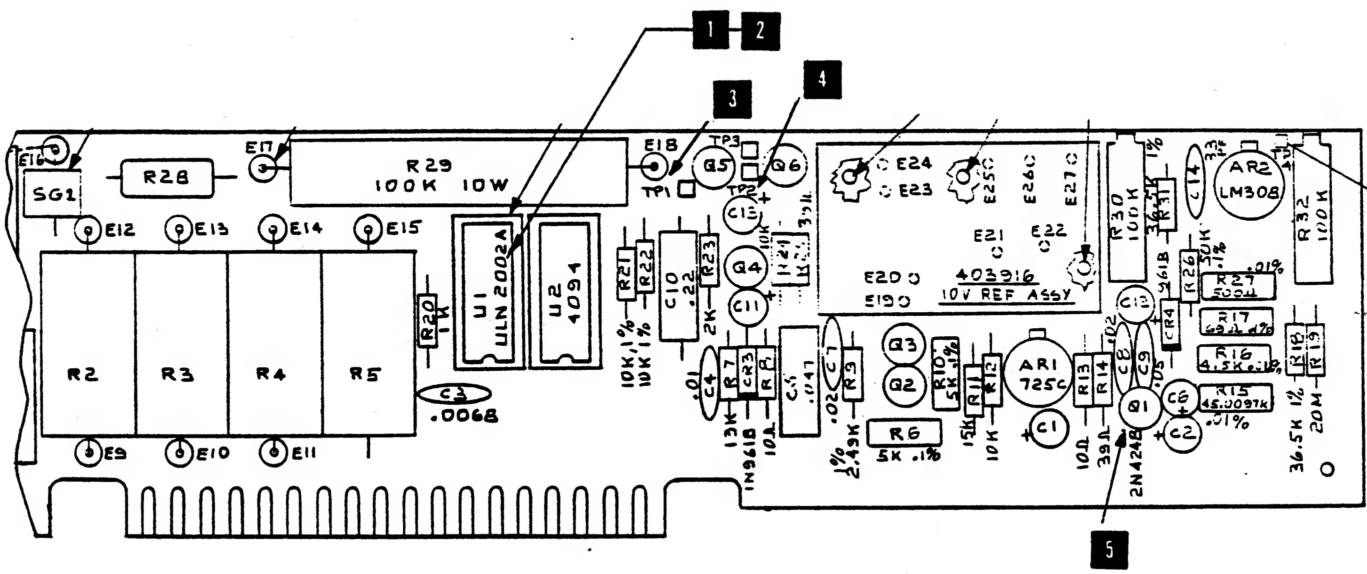


Figure 6.28 - Attenuator/Reference Component Location Diagram

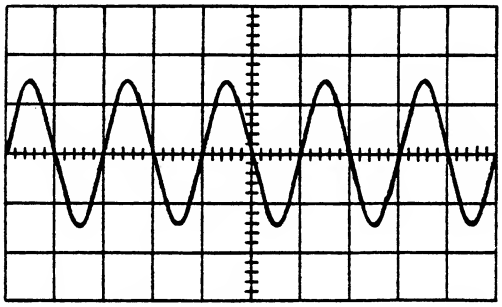
Table 6.22 - RMS Converter Subassembly Performance Test

Input and Control Setting	Signal Nomenclature	Reference Designation	Test Point	Illustration Reference	Performance Standard
Function: AC Range: 1 Volt Input Terminals: Connect +IN to –IN with a copper wire jumper	All measurements are referenced to Analog Common (Mecca).				
		TP4	1	Figure 6.29	0.0 VDC
		Q16-C	2	Figure 6.29	0.9 VDC
		TP2	3	Figure 6.29	0.0 VDC
	Scaling Amp input	J304-1	4	Figure 6.29	0.0 VDC
	Scaling Amp output	TP3	5	Figure 6.29	0.0 VDC
	RMS Converter Amp output	AR1-6	6	Figure 6.29	0.0 VDC
	RMS Converter output	J304-12	7	Figure 6.29	0.0 VDC
Range: 10V Remove jumper. Connect input to a signal generator set for 10V RMS @ 1 KHz	All waveforms are synced to the positive edge of the internal sync.				
	Scaling Amp output	TP3	A	Figure 6.29	Waveform 1
	Absolute Value output	TP4	B	Figure 6.29	Waveform 2
	Log Amp	Emitters of Q3	C	Figure 6.29	Waveform 3
	Output Amp	AR1 pin 6 (Scope AC coupled)	D	Figure 6.29	Waveform 4

WAVEFORMS FOR TABLE 6.22

1 (NO.) TP-3

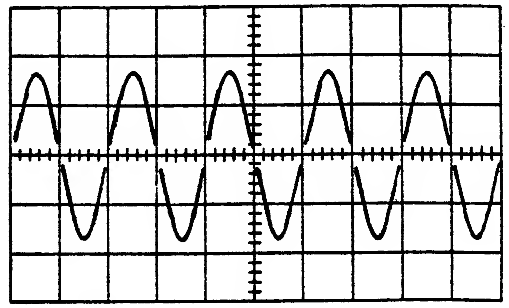
1V (V/DIV)



.5mS (S/DIV)

2 (NO.) TP-4

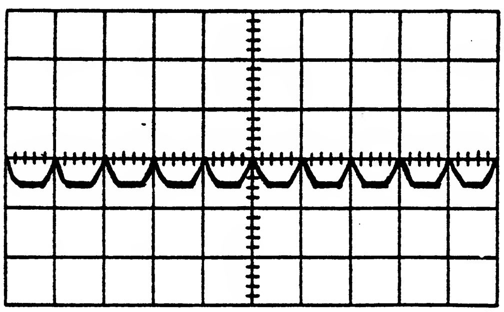
1V (V/DIV)



.5mS (S/DIV)

3 (NO.) Q3 EMITTERS

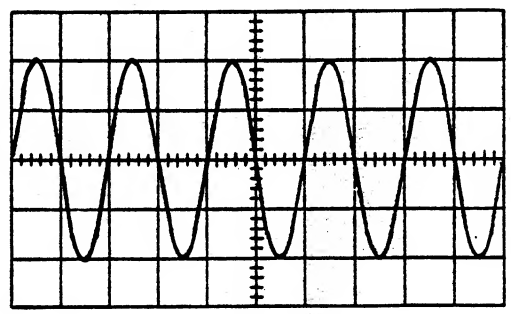
.5V (V/DIV)



.5mS (S/DIV)

4 (NO.) AR1 PIN 6

20mV (V/DIV)



.5mS (S/DIV)

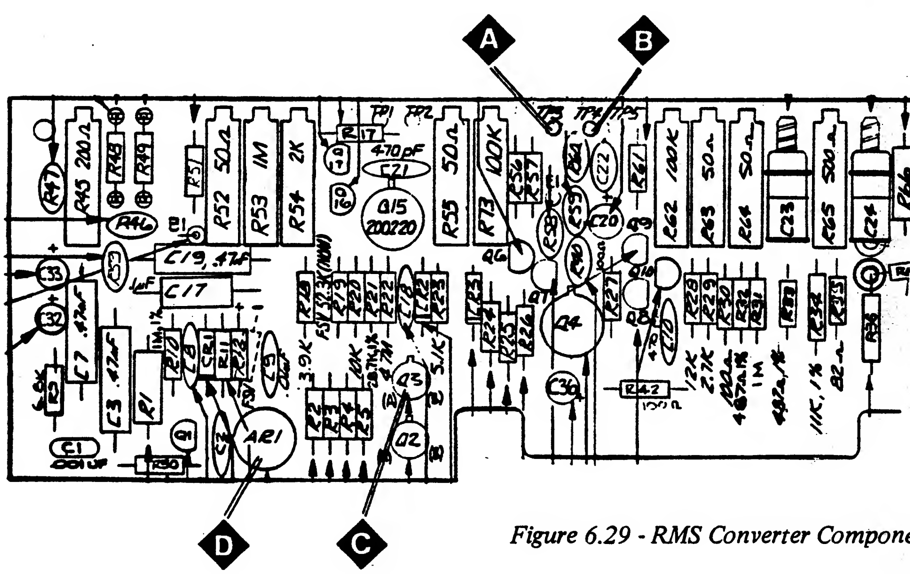
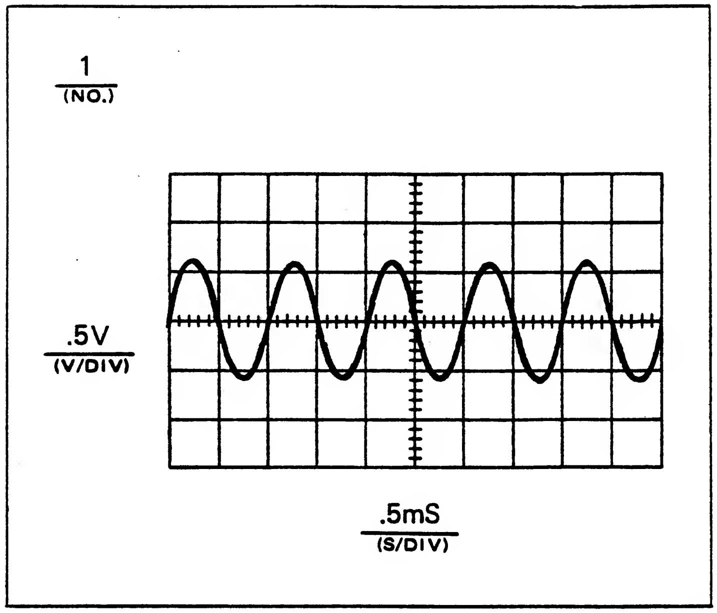


Figure 6.29 - RMS Converter Component Location Diagram

Table 6.23 - Scaling Amplifier Subassembly Performance Test

Input and Control Setting	Signal Nomenclature	Reference Designation	Test Point	Illustration Reference	Performance Standard
All waveforms are synced to the positive edge of the internal sync.					
Function: AC Range: 1 Volt Connect input to a signal generator set for 1.0V RMS at 1 KHz	Scaling Amp output	C46 (minus side)	A	Figure 6.30	Waveform 1
Function: AC Range: 10 Volts Connect input to a signal generator set for 10V RMS at 1 KHz	Scaling Amp output	C46 (minus side)	A	Figure 6.30	Waveform 1
Function: AC Range: 100 Volts Connect input to a signal generator set for 100V RMS at 1 KHz	Scaling Amp output	C46 (minus side)	A	Figure 6.30	Waveform 1
Function: AC Range: 1KV Connect input to a signal generator set for 1 KV RMS at 1 KHz	Scaling Amp	C46 (minus side)	A	Figure 6.30	Waveform 1

WAVEFORM FOR TABLE 6.23



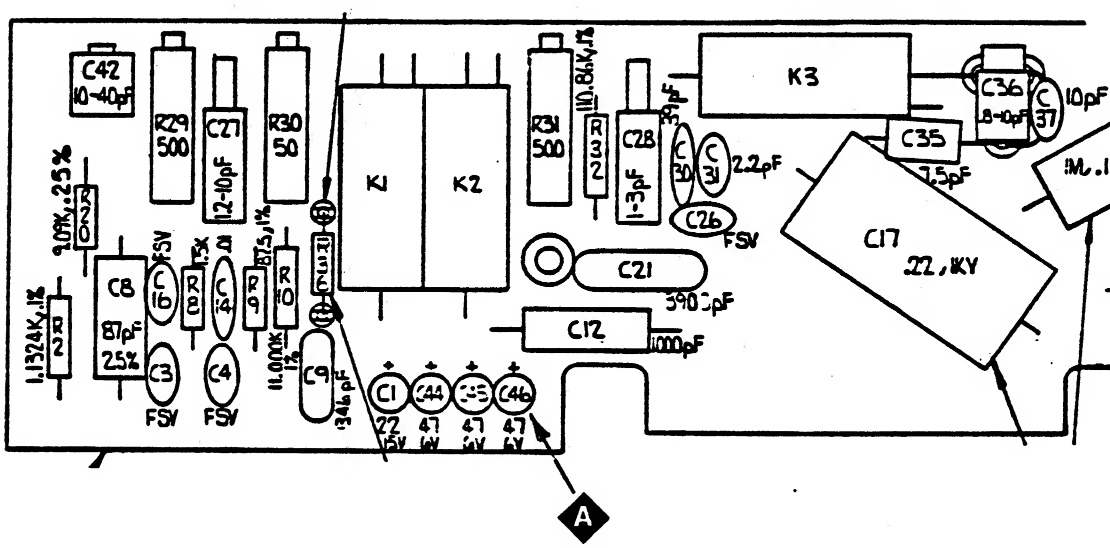


Figure 6.30 - Scaling Amplifier Component Location Diagram

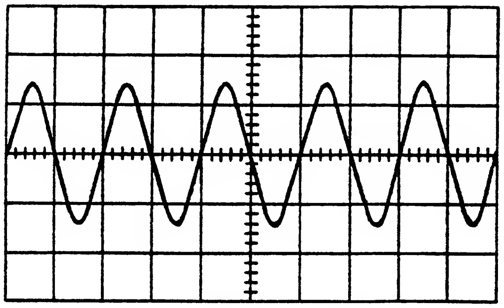
Table 6.24 - AC Averaging Converter Subassembly Performance Test

Input and Control Setting	Signal Nomenclature	Reference Designation	Test Point	Illustration Reference	Performance Standard
Function: AC Range: 10 Volts Input Terminals: Connect +IN to –IN with copper wire jumper	All measurements are referenced to Analog Common (Mecca).				
	Converter input	TP3	1	Figure 6.31	0.0 VDC (nominal)
	Absolute Value output	TP7	2	Figure 6.31	0.0 VDC (nominal)
	Halfwave output	TP6	3	Figure 6.31	0.0 VDC (nominal)
	Converter output	TP4	4	Figure 6.31	0.0 VDC (nominal)
Remove jumper. Connect input to a signal generator set for 1.9V RMS at 1 KHz	All waveforms are synced to the positive edge of the internal sync.				
	Converter input	TP3	A	Figure 6.31	Waveform 1
	Absolute Value output	TP7	B	Figure 6.31	Waveform 2
	Halfwave output	TP6	C	Figure 6.31	Waveform 3
	Converter output	TP4	D	Figure 6.31	Waveform 4

WAVEFORMS FOR TABLE 6.24

1 (NO.) TP3

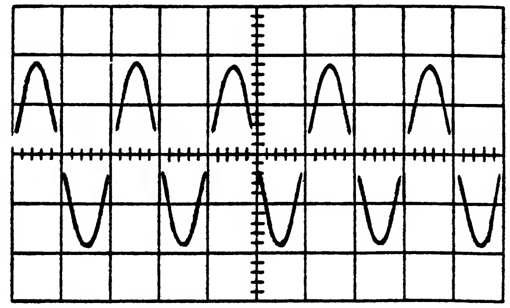
1V (V/DIV)



.5mS (S/DIV)

2 (NO.) TP7

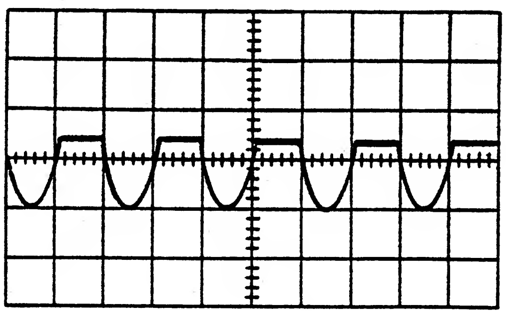
2V (V/DIV)



.5mS (S/DIV)

3 (NO.)

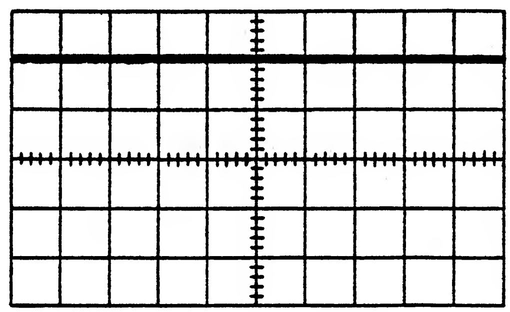
2V (V/DIV)



.5mS (S/DIV)

4 (NO.)

.5V (V/DIV)



.5mS (S/DIV)

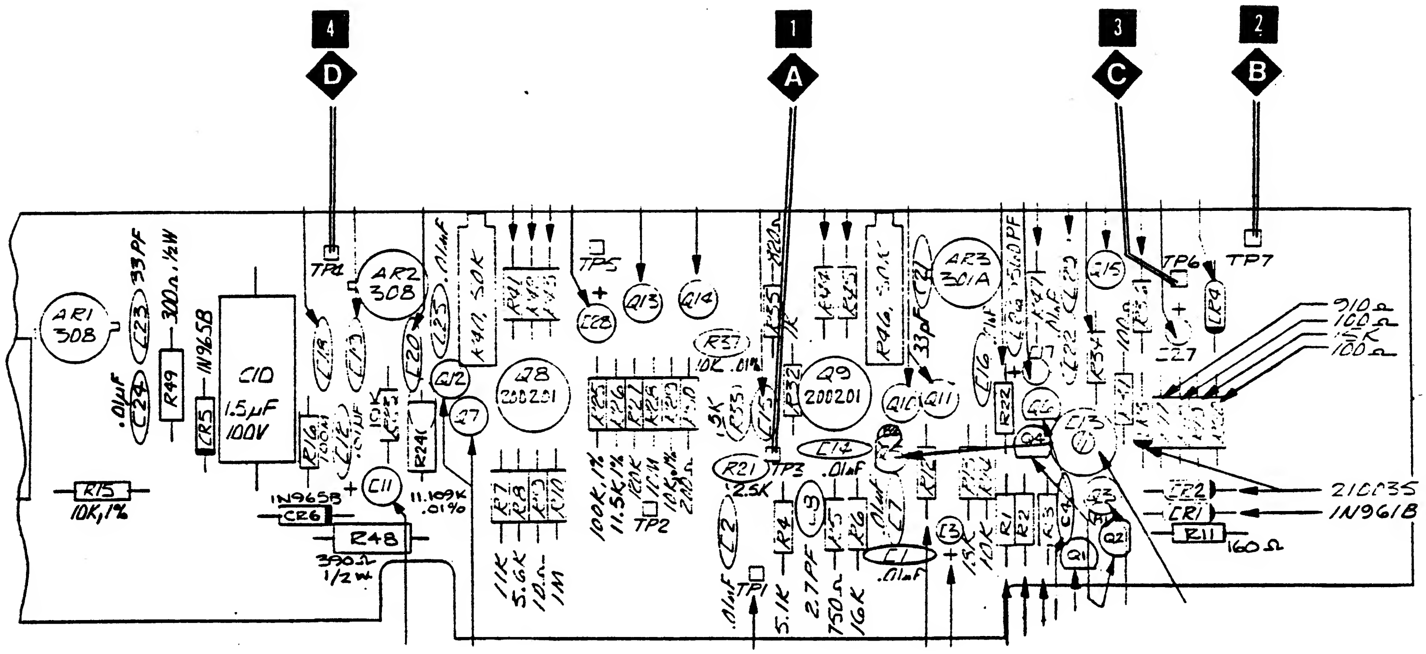
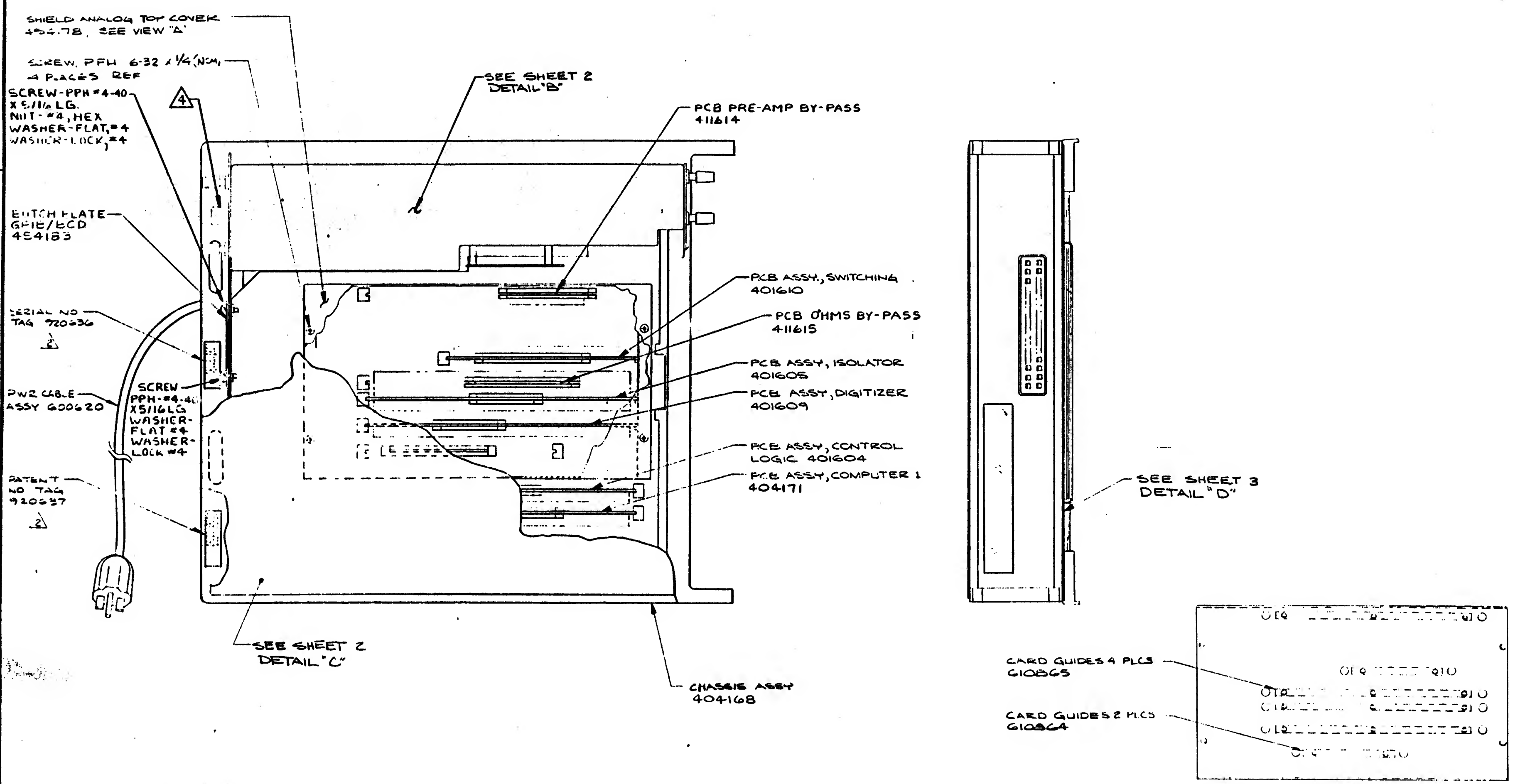


Figure 6.31 - AC Averaging Converter Component Location Diagram



5. HOUSING TABS TO BE BENT FLAT AGAINST INSIDE OF BOTTOM COVER.

4. AFTER INSTALLATION OF CAL MODULE ASSY SECURE LATCH ON REAR PANEL TO BASE PLATE.

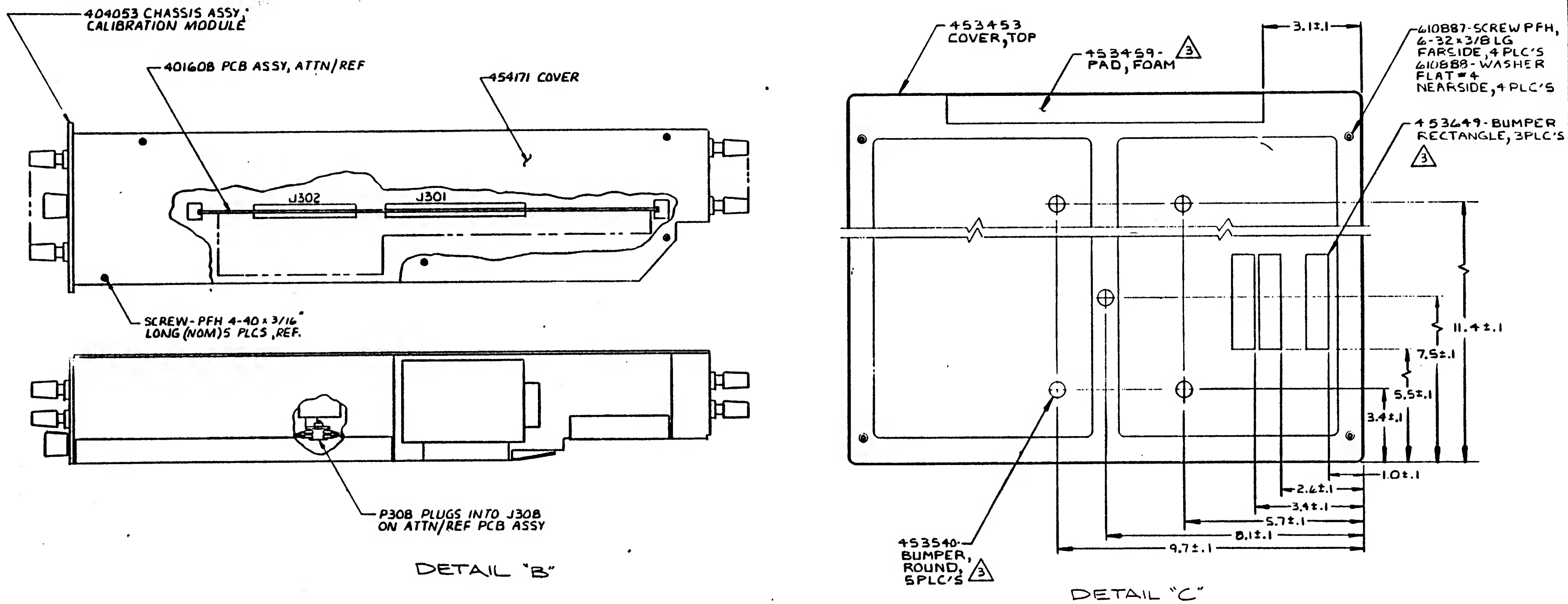
3. REMOVE PROTECTIVE BACKING FROM FOAM PAD, ROUND + RECTANGULAR BUMPERS + ATTACH TO INSIDE OF TOP OR BOTTOM COVER AS SHOWN.

2. TYPE PERTINENT DATA ON SERIAL NO LABEL, ATTACH SERIAL & PATENT NO LABELS TO BOTTOM FRAME APPROX. AS SHOWN.

1. ASSEMBLE PER RACAL-DANA WORKMANSHIP MANUAL.

NOTES: UNLESS OTHERWISE SPECIFIED

MULTIMETER ASSY, DIGITAL, 6000			
SIZE	CODE IDENT NO	DWG NO.	REV
D	21793	404193	A
SCALE NONE		SHEET 1 OF 5	



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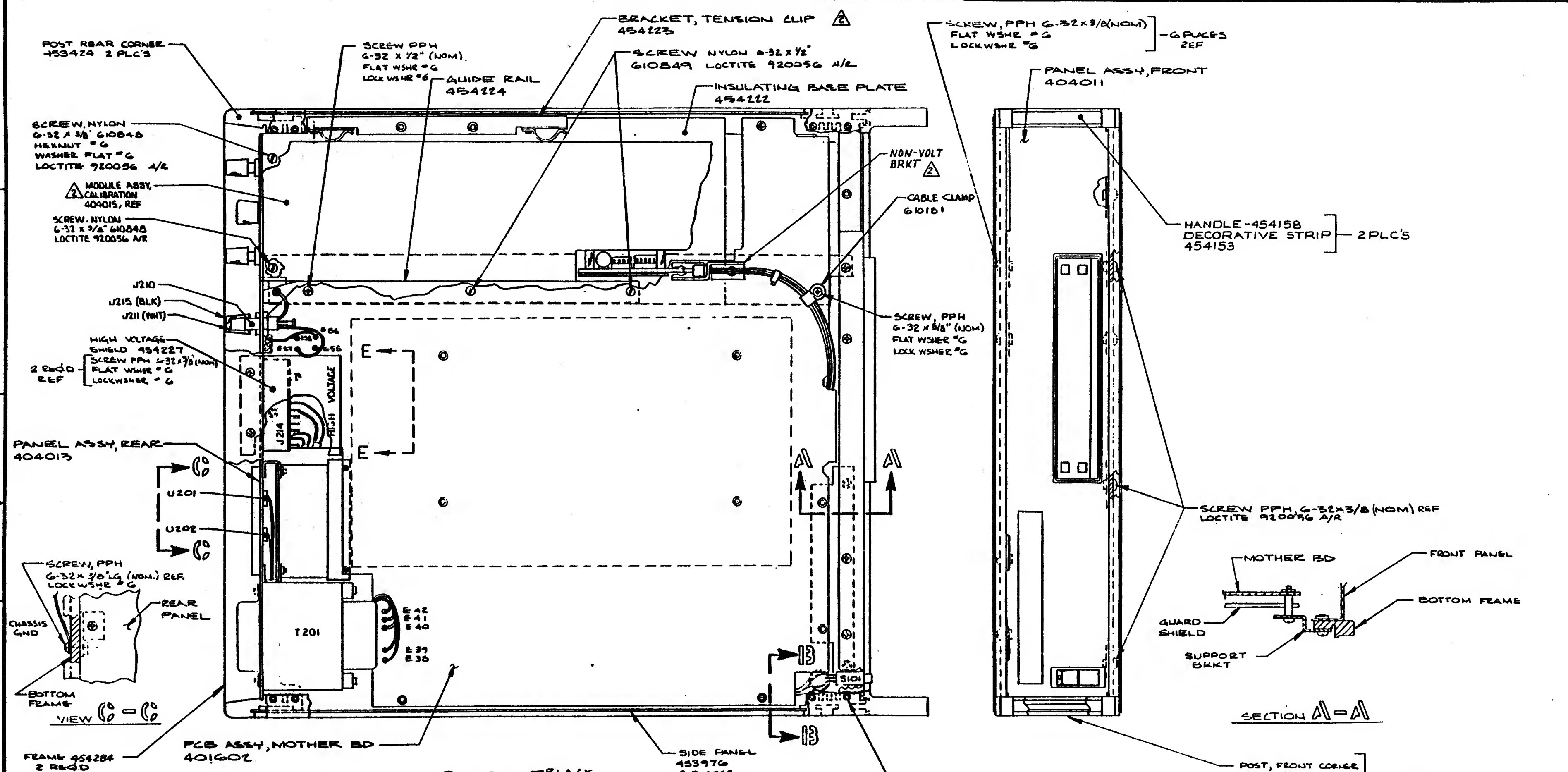
NOTES: UNLESS OTHERWISE SPECIFIED

MULTIMETER ASSY, DIGITAL, 6000

SIZE	CODE IDENT NO	DWG NO.	REV
D	21793	404193	F

SCALE 1/2:1E — SHEET 2 OF 5



4. TRANSFORMER SECONDARY #2 CABLE: LAY SHIELDS BACK AWAY FROM WIRES, SOLDER WHT/GRN WIRE TO INNER SHIELD & COVER WITH SHRINK TUBING. SOLDER GRN. WIRE TO OUTER SHIELD & COVER ENTIRE CABLE WITH SHRINK TUBING AS SHOWN.

3. TAG & IDENTIFY WITH DANA P/N & CURRENT REV LTR.

2. CAL MODULE TO BE USED AS AN ALIGNMENT FIXTURE AFTER INSTALLATION OF CAL MOD ASSY SECURE LATCH ON REAR PANEL TO BASE PLATE, ADJUST NON-VOLT BRKT ON MOTHER BD, MOVE TENSION CLIP BRKT TOWARD CAL MOD AND TIGHTEN TO BOTTOM FRAME.

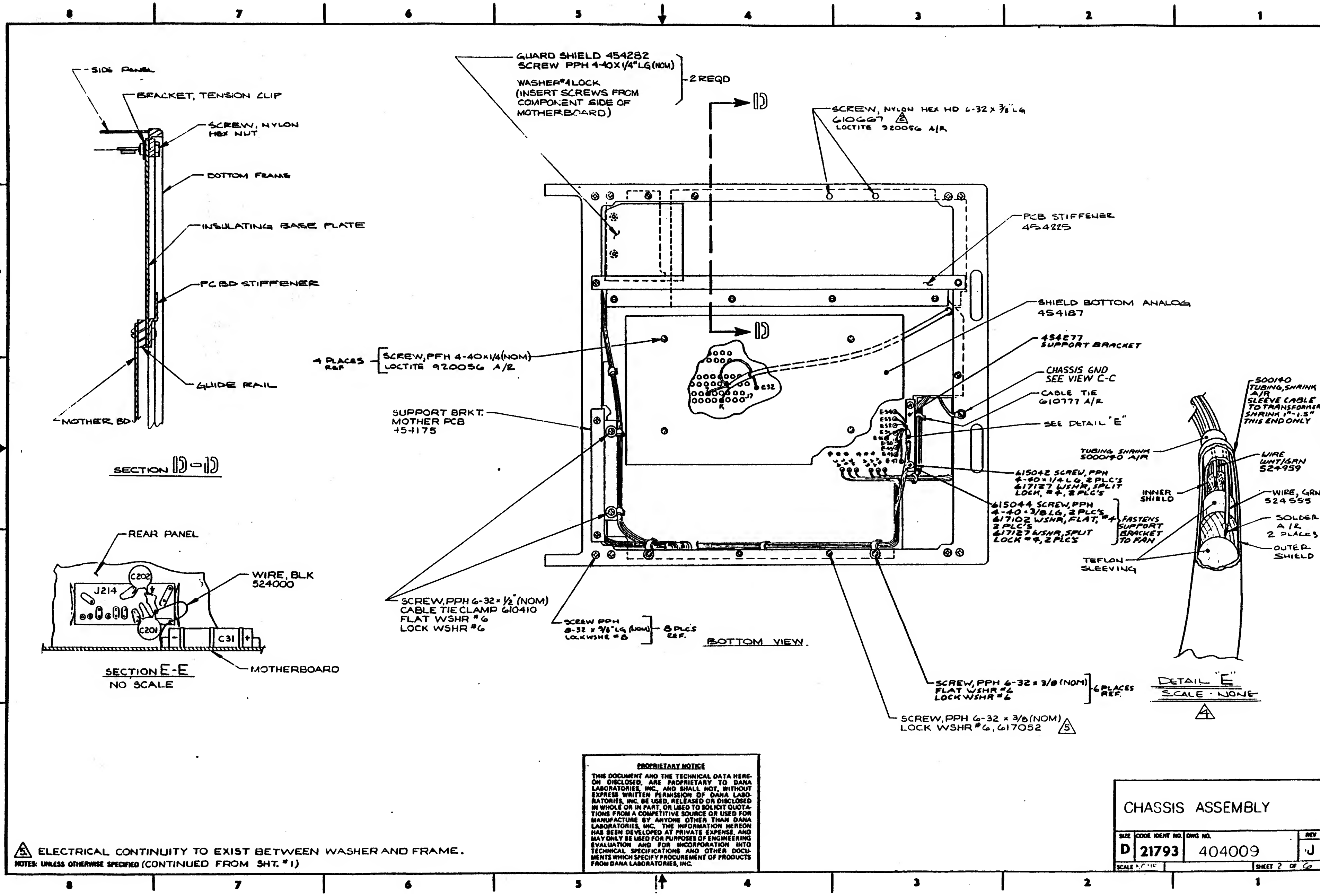
1. ASSEMBLE PER DANA WORKMANSHIP MANUAL.

NOTES: UNLESS OTHERWISE SPECIFIED

CHASSIS ASSEMBLY

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	404009	J

SCALE NONE — SHEET 1 OF 1



SIDE PANEL
BRACKET, TENSION CLIP
SCREW, NYLON HEX NUT
BOTTOM FRAME
INSULATING BASE PLATE
PC BD STIFFENER
GUIDE RAIL
MOTHER BD
SECTION D-D
REAR PANEL
J214
C202
C201
C31
WIRE, BLK 524000
MOTHERBOARD
SECTION E-E
NO SCALE
GUARD SHIELD 454282
SCREW PPH 4-40X1/4"LG(NOM)
WASHER #4LOCK
(INSERT SCREWS FROM COMPONENT SIDE OF MOTHERBOARD)
2 REQD
SCREW, NYLON HEX HD 6-32 x 3/8"LG
610667
LOCTITE 920056 A/R
PCB STIFFENER 454225
SHIELD BOTTOM ANALOG 454187
454277 SUPPORT BRACKET
CHASSIS GND SEE VIEW C-C
CABLE TIE 610777 A/R
SEE DETAIL "E"
4 PLACES REF
SCREW, PFH 4-40x1/4(NOM)
LOCTITE 920056 A/R
SUPPORT BRKT. MOTHER PCB 454175
E32
615042 SCREW, PPH 4-40x1/4 LG, 2 PLC'S 617127 WSHR, SPLIT LOCK, #4, 2 PLC'S
615044 SCREW, PPH 4-40x3/8 LG, 2 PLC'S 617102 WSHR, FLAT, #4, 2 PLC'S 617127 WSHR, SPLIT LOCK #4, 2 PLC'S
FASTENS SUPPORT BRACKET TO FAN
SCREW, PPH 6-32 x 1/2"(NOM)
CABLE TIE CLAMP 610410
FLAT WSHR #6
LOCK WSHR #6
SCREW PPH 8-32 x 3/8"LG (NOM) LOCKWSHR #8
8 PLC'S REF.
BOTTOM VIEW
SCREW, PPH 6-32 x 3/8(NOM)
FLAT WSHR #6
LOCK WSHR #6
6 PLACES REF.
SCREW, PPH 6-32 x 3/8(NOM)
LOCK WSHR #6, 617052
500140 TUBING, SHRINK A/R SLEEVE CABLE TO TRANSFORMER SHRINK 1"-1.5" THIS END ONLY
TUBING SHRINK 500040 A/R
WIRE WHT/GRN 524959
INNER SHIELD
WIRE, GRN 524555
SOLDER A/R 2 PLACES
OUTER SHIELD
TEFLON SLEEVING
DETAIL "E"
SCALE · NONE
ELECTRICAL CONTINUITY TO EXIST BETWEEN WASHER AND FRAME.
NOTES: UNLESS OTHERWISE SPECIFIED (CONTINUED FROM SHT. #1)
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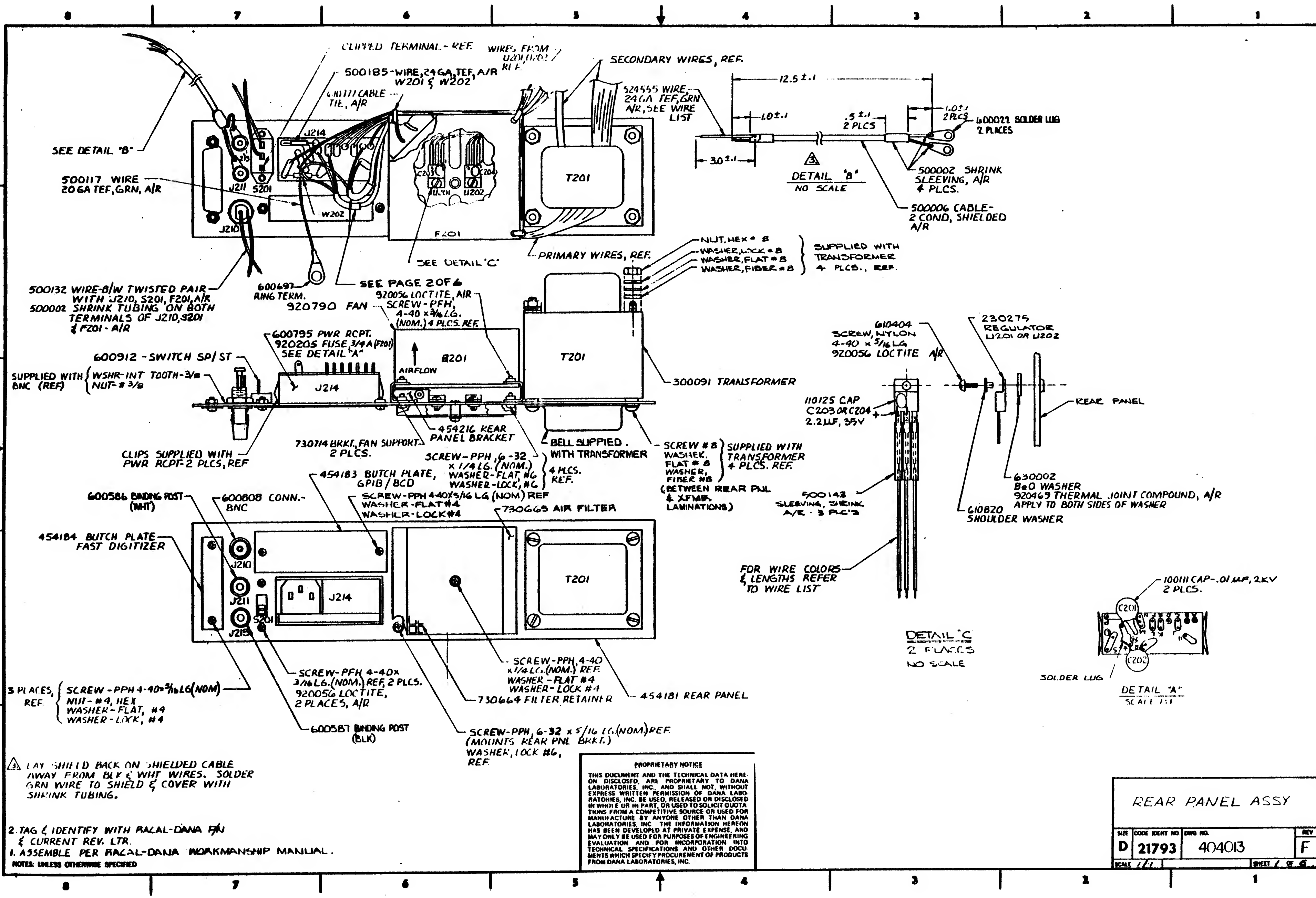
CHASSIS ASSEMBLY
SIZE D
CODE IDENT NO. 21793
DWG NO. 404009
REV J
SHEET 2 OF 6



CLIPPED TERMINAL - REF.
WIRES FROM U201, U202 REF.
500185-WIRE, 24GA, TEF, A/R W201 & W202
600177 CABLE TIE, A/R
SECONDARY WIRES, REF.
524555 WIRE-24GA TEF, GRN A/R, SEE WIRE LIST
SEE DETAIL "B"
500117 WIRE 20GA TEF, GRN, A/R
J214
J211
S201
J210
W202
C203
C204
U201
U202
F201
T201
SEE DETAIL 'C'
PRIMARY WIRES, REF.
500132 WIRE-B/W TWISTED PAIR WITH J210, S201, F201, A/R
500002 SHRINK TUBING ON BOTH TERMINALS OF J210, S201 & F201 - A/R
600697 RING TERM.
SEE PAGE 2 OF 6
920056 LOCTITE, A/R
920790 FAN
SCREW-PFH, 4-40 x 3/16 LG. (NOM.) 4 PLCS. REF.
600795 PWR RCPT.
920205 FUSE 3/4A (F201)
SEE DETAIL "A"
600912 - SWITCH SP/ST
SUPPLIED WITH BNC (REF) { WSHR-INT TOOTH-3/8, NUT-# 3/8
AIRFLOW
B201
300091 TRANSFORMER
NUT, HEX # 8
WASHER, LOCK # 8
WASHER, FLAT # 8
WASHER, FIBER # 8
SUPPLIED WITH TRANSFORMER 4 PLCS., REF.
454216 REAR PANEL BRACKET
730714 BRKT, FAN SUPPORT-2 PLCS.
CLIPS SUPPLIED WITH PWR RCPT-2 PLCS, REF
BELL SUPPLIED WITH TRANSFORMER
SCREW-PPH, 6-32 x 1/4 LG. (NOM.) WASHER-FLAT, #6 WASHER-LOCK, #6 4 PLCS. REF.
SCREW # 8 WASHER, FLAT # 8 WASHER, FIBER #8 (BETWEEN REAR PNL & XFMR LAMINATIONS) SUPPLIED WITH TRANSFORMER 4 PLCS. REF.
454183 BUTCH PLATE, GPIB/BCD
SCREW-PPH 4-40 x 5/16 LG (NOM) REF
WASHER-FLAT #4
WASHER-LOCK #4
730665 AIR FILTER
600586 BINDING POST (WHT)
600808 CONN.-BNC
454184 BUTCH PLATE FAST DIGITIZER
J215
3 PLACES, REF { SCREW-PPH 4-40 x 5/16 LG (NOM), NUT-#4, HEX, WASHER-FLAT, #4, WASHER-LOCK, #4
SCREW-PFH 4-40 x 3/16 LG. (NOM.) REF, 2 PLCS. 920056 LOCTITE, 2 PLACES, A/R
600587 BINDING POST (BLK)
SCREW-PPH 4-40 x 1/4 LG. (NOM.) REF WASHER-FLAT #4 WASHER-LOCK #4
730664 FILTER RETAINER
454181 REAR PANEL
SCREW-PPH, 6-32 x 5/16 LG. (NOM) REF (MOUNTS REAR PNL BRKT.) WASHER, LOCK #6, REF
12.5 ±.1
1.0 ±.1
3.0 ±.1
.5 ±.1 2 PLCS
1.0 ±.1 2 PLCS
600022 SOLDER LUG 2 PLACES
500002 SHRINK SLEEVING, A/R 4 PLCS.
500006 CABLE-2 COND, SHIELDED A/R
3
DETAIL 'B'
NO SCALE
610404 SCREW, NYLON 4-40 x 5/16 LG 920056 LOCTITE A/R
230275 REGULATOR U201 OR U202
110125 CAP C203 OR C204 2.2µF, 35V
REAR PANEL
630002 BeO WASHER
920469 THERMAL JOINT COMPOUND, A/R APPLY TO BOTH SIDES OF WASHER
610820 SHOULDER WASHER
500143 SLEEVING, SHRINK A/R - 3 PLC'S
FOR WIRE COLORS & LENGTHS REFER TO WIRE LIST
DETAIL 'C'
2 PLACES
NO SCALE
100111 CAP-.01 µF, 2KV 2 PLCS.
C201
C202
SOLDER LUG
DETAIL "A"
SCALE 1:1
3 LAY SHIELD BACK ON SHIELDED CABLE AWAY FROM BLK & WHT WIRES. SOLDER GRN WIRE TO SHIELD & COVER WITH SHRINK TUBING.
2. TAG & IDENTIFY WITH RACAL-DANA P/N & CURRENT REV. LTR.
1. ASSEMBLE PER RACAL-DANA WORKMANSHIP MANUAL.
NOTES: UNLESS OTHERWISE SPECIFIED
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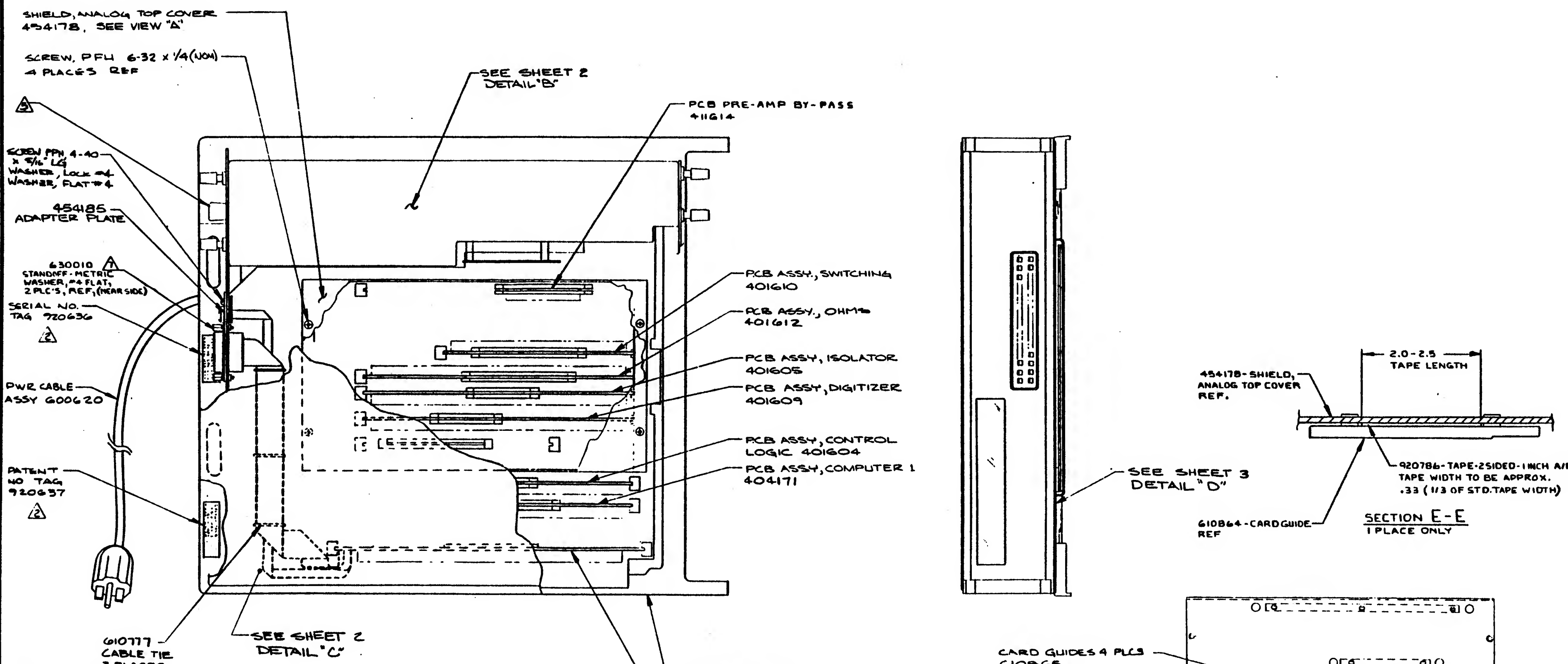
REAR PANEL ASSY
SIZE D
CODE IDENT NO 21793
DWG NO. 404013
REV F
SCALE 1/1
SHEET 1 OF 6



8. LABEL TO SHOW DVM MODEL NO., CAL MODULE S/N + OPTIONS WHICH ARE INSTALLED IN THE CAL MODULE. LABEL TO BE FLUSH WITH CORNERS OF REAR PANEL.

7. DISCARD NUTS & LOCKWASHERS.

6. HOUSING TABS TO BE BENT FLAT AGAINST INSIDE OF BOTTOM COVER.

5. AFTER INSTALLATION OF CAL MODULE ASSY SECURE LATCH ON REAR PANEL TO BASE PLATE.

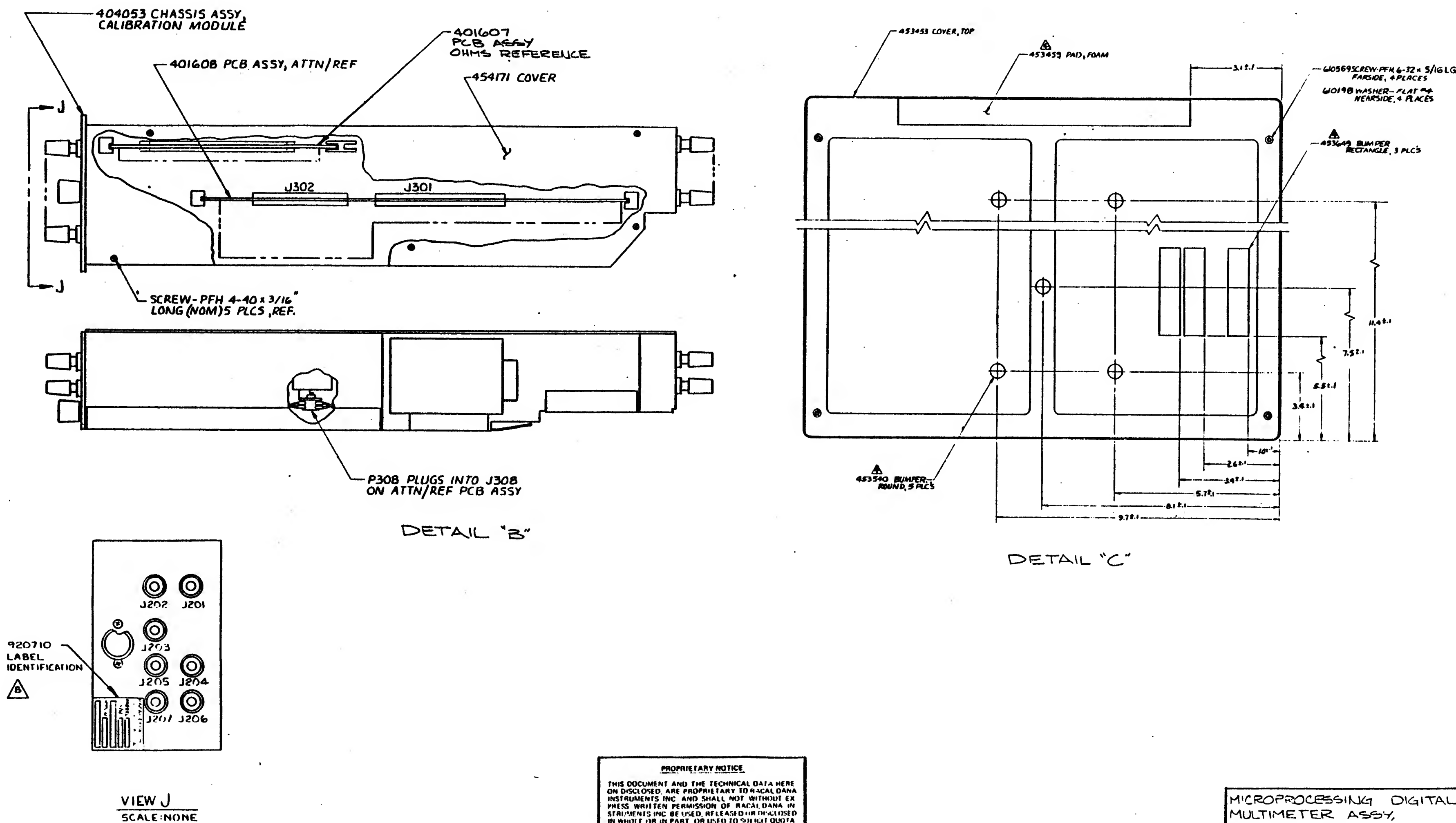
4. REMOVE PROTECTIVE BACKING FROM FOAM PAD, ROUND & RECTANGULAR BUMPERS & ATTACH TO INSIDE OF TOP OR BOTTOM COVER AS SHOWN.

2. TYPE PERTINENT DATA ON SERIAL NO. LABEL, ATTACH SERIAL & PATENT NO LABELS TO BOTTOM FRAME APPROX. AS SHOWN.

1 ASSEMBLE PER DANA WORKMANSHIP MANUAL.

NOTES: UNLESS OTHERWISE SPECIFIED

MICROPROCESSING DIGITAL MULTIMETER ASSY, SERIES 6001			
SIZE	CODE IDENT NO	DWG NO.	REV
D	21793	404167	J
SCALE NONE		SHEET 1 OF 3	



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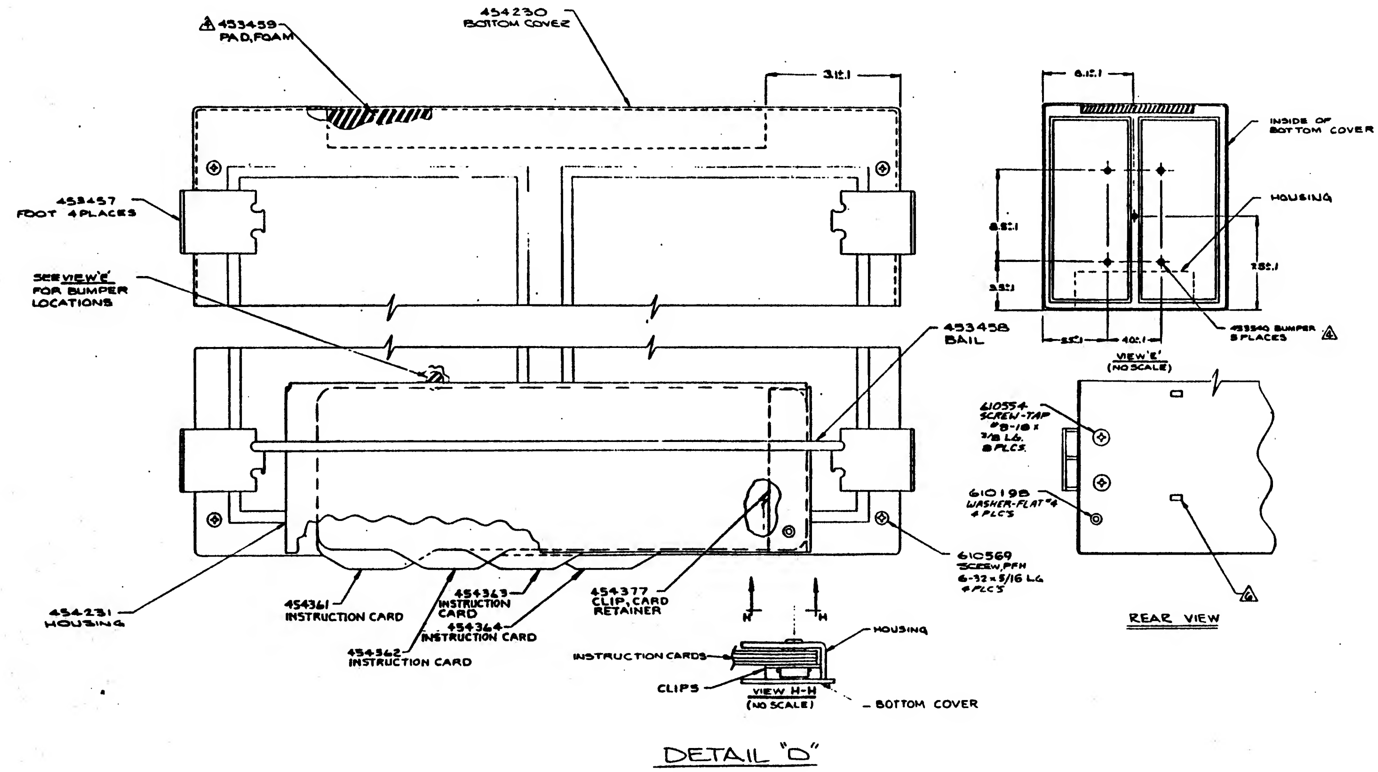
NOTES: UNLESS OTHERWISE SPECIFIED

MICROPROCESSING DIGITAL MULTIMETER ASSY, SERIES 6001			
SIZE	CODE IDENT NO	DWG NO.	REV
D	21793	404167	J
SCALE		SHEET 2 OF 6	

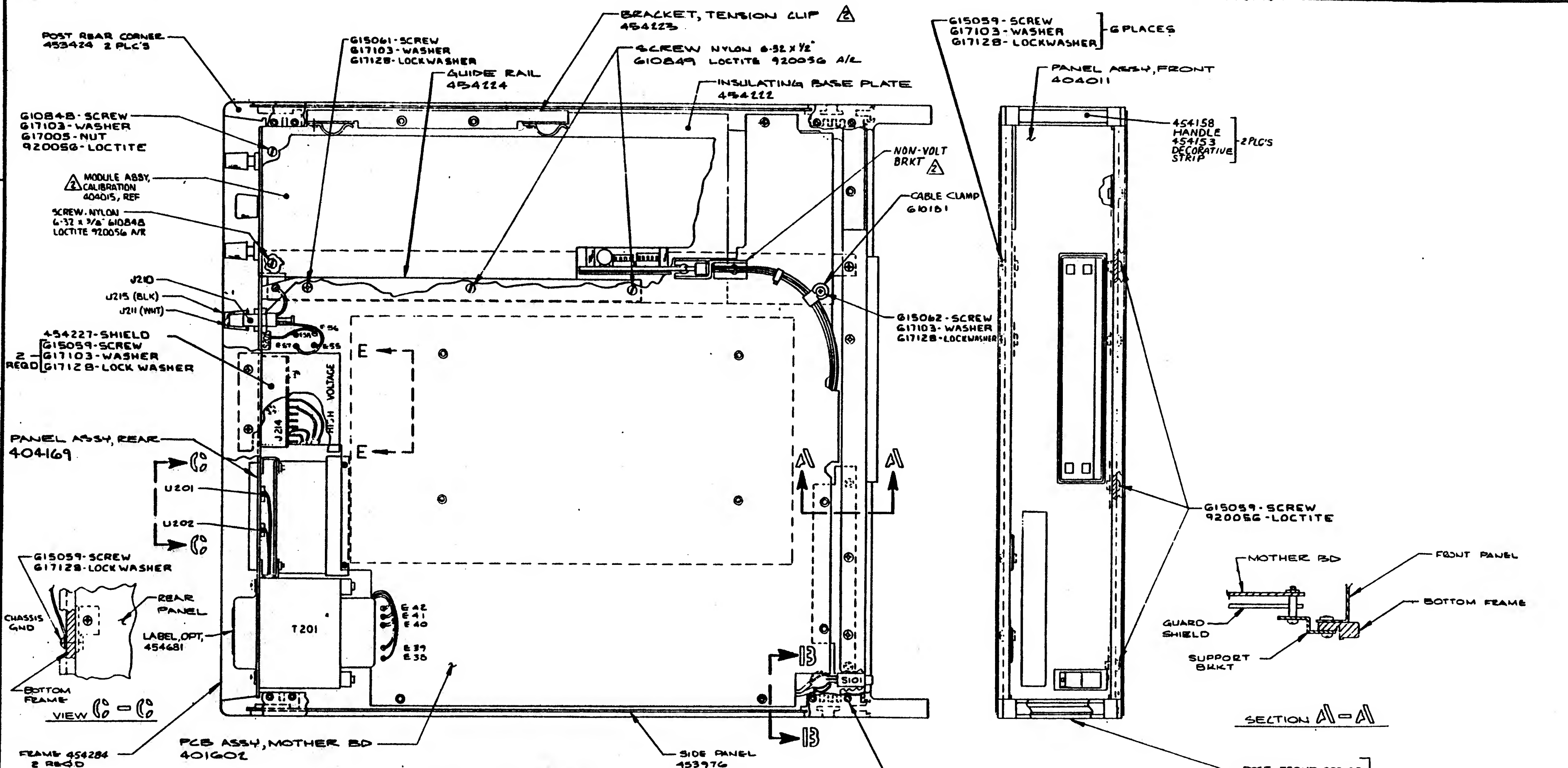


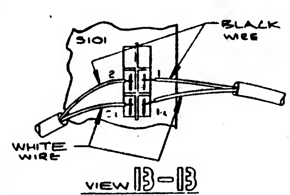
NOTES: UNLESS OTHERWISE SPECIFIED

MICROROCESSING DIGITAL MULTIMETER ASSY SERIES 6001

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	404167	J

SHEET 5 OF 6





4. TRANSFORMER SECONDARY #2 CABLE: LAY SHIELDS BACK AWAY FROM WIRES, SOLDER WHT/GRN WIRE TO INNER SHIELD & COVER WITH SHRINK TUBING. SOLDER GRN WIRE TO OUTER SHIELD & COVER ENTIRE CABLE WITH SHRINK TUBING AS SHOWN.

3. TAG & IDENTIFY WITH DANA P/N & CURRENT REV LTR.

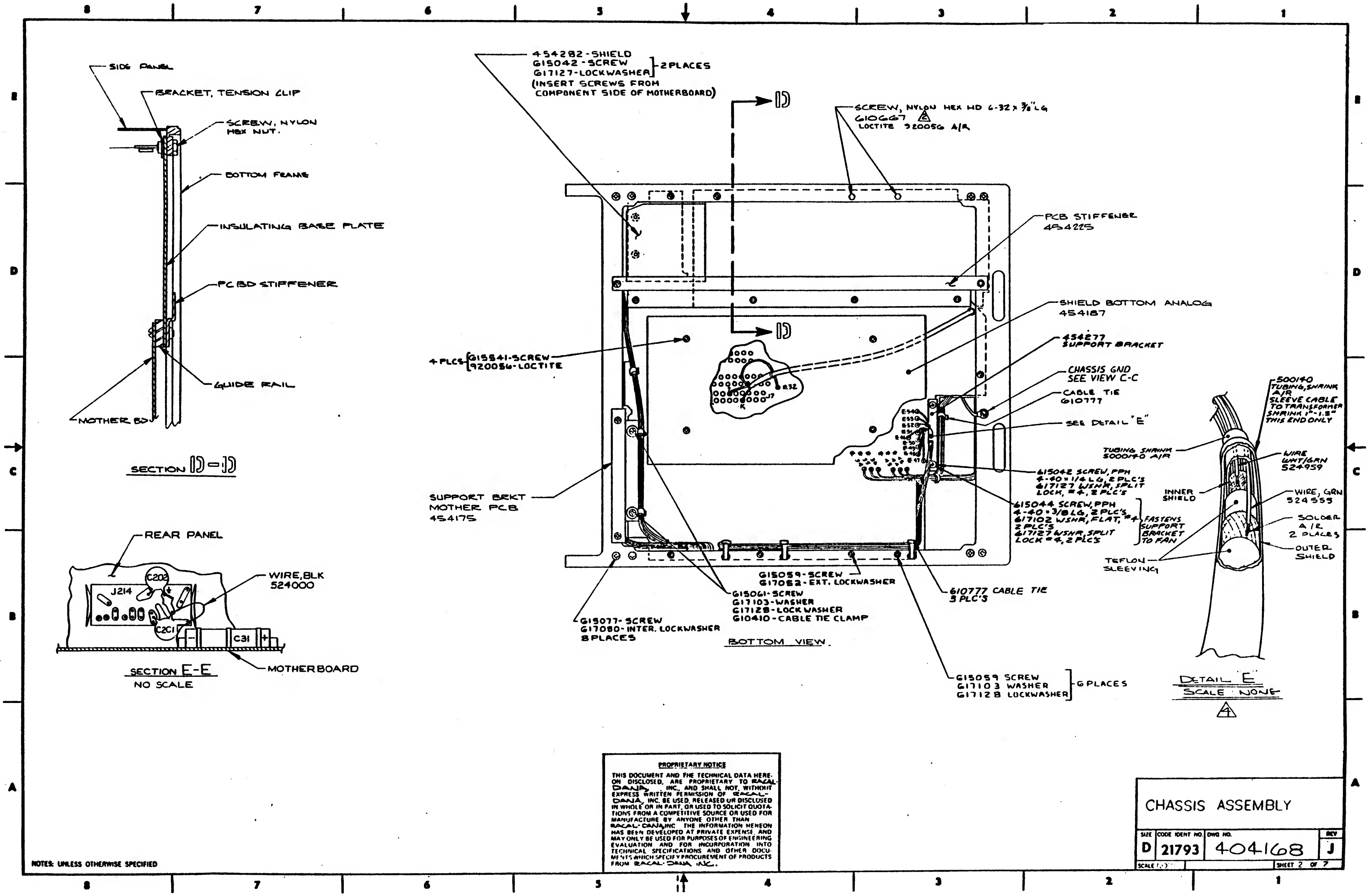
2. CAL MODULE TO BE USED AS AN ALIGNMENT FIXTURE AFTER INSTALLATION OF CAL MOD ASSY SECURE LATCH ON REAR PANEL TO BASE PLATE, ADJUST NON-VOLT BRKT ON MOTHER BD, MOVE TENSION CLIP BRKT TOWARD CAL MOD AND TIGHTEN TO BOTTOM FRAME.

1. ASSEMBLE PER RACAL-DANA WORKMANSHIP MANUEL.

NOTES: UNLESS OTHERWISE SPECIFIED

CHASSIS ASSEMBLY

SIZE	CODE IDENT NO	DWG NO.	REV
D	21793	404168	J
SCALE NONE		SHEET 1 OF 7	


SIDE PANEL
BRACKET, TENSION CLIP
SCREW, NYLON HEX NUT.
BOTTOM FRAME
INSULATING BASE PLATE
PC BD STIFFENER
GUIDE RAIL
MOTHER BD
SECTION D-D
REAR PANEL
WIRE, BLK 524000
J214
C202
C201
C31
MOTHERBOARD
SECTION E-E
NO SCALE
454282-SHIELD
G15042-SCREW
G17127-LOCKWASHER
2 PLACES
(INSERT SCREWS FROM COMPONENT SIDE OF MOTHERBOARD)
SCREW, NYLON HEX HD 6-32 x 3/8" LG
G10667
LOCTITE 920056 A/R
PCB STIFFENER 454225
SHIELD BOTTOM ANALOG 454187
454277 SUPPORT BRACKET
CHASSIS GND SEE VIEW C-C
CABLE TIE G10777
SEE DETAIL "E"
4 PLCS
G15541-SCREW
920056-LOCTITE
SUPPORT BRKT MOTHER PCB 454175
G15042 SCREW, PPH 4-40 x 1/4 LG, 2 PLC'S
G17127 WSHR, SPLIT LOCK, #4, 2 PLC'S
G15044 SCREW, PPH 4-40 x 3/8 LG, 2 PLC'S
G17102 WSHR, FLAT, #4 2 PLC'S
G17127 WSHR, SPLIT LOCK #4, 2 PLC'S
FASTENS SUPPORT BRACKET TO FAN
G15059-SCREW
G17052-EXT. LOCKWASHER
G15061-SCREW
G17103-WASHER
G17128-LOCK WASHER
G10410-CABLE TIE CLAMP
G15077-SCREW
G17080-INTER. LOCKWASHER
8 PLACES
BOTTOM VIEW
G10777 CABLE TIE 3 PLC'S
G15059 SCREW
G17103 WASHER
G17128 LOCKWASHER
6 PLACES
500140 TUBING, SHRINK A/R
SLEEVE CABLE TO TRANSFORMER SHRINK 1"-1.5" THIS END ONLY
TUBING, SHRINK 500040 A/R
WIRE WHT/GRN 524959
INNER SHIELD
WIRE, GRN 524555
SOLDER A/R 2 PLACES
OUTER SHIELD
TEFLON SLEEVING
DETAIL E
SCALE NONE
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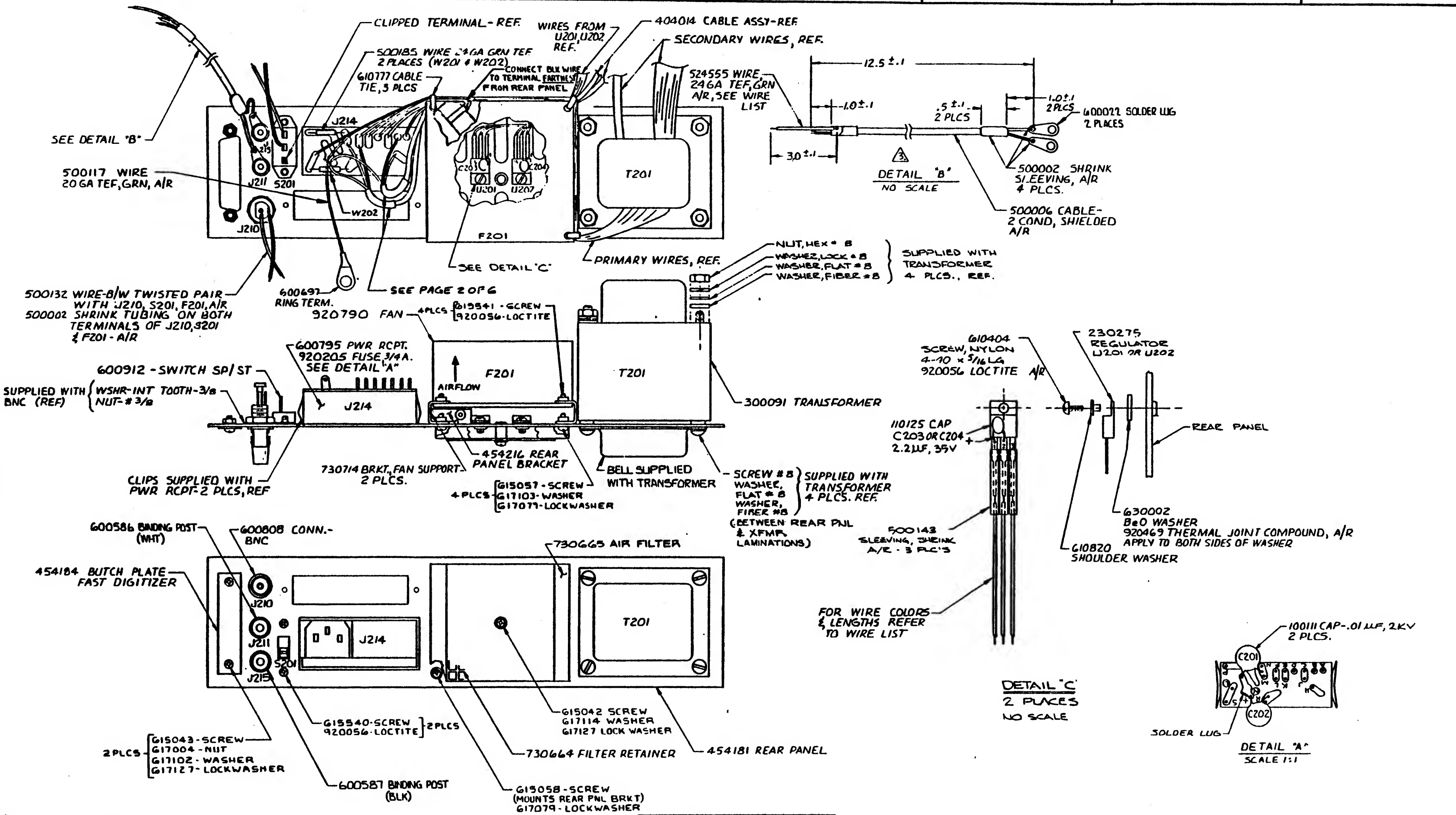
NOTES: UNLESS OTHERWISE SPECIFIED
CHASSIS ASSEMBLY
SIZE D
CODE IDENT NO. 21793
DWG NO. 404168
REV J
SHEET 2 OF 7



3 LAY SHIELD BACK ON SHIELDED CABLE AWAY FROM BLK & WHT WIRES. SOLDER GRN WIRE TO SHIELD & COVER WITH SHRINK TUBING.

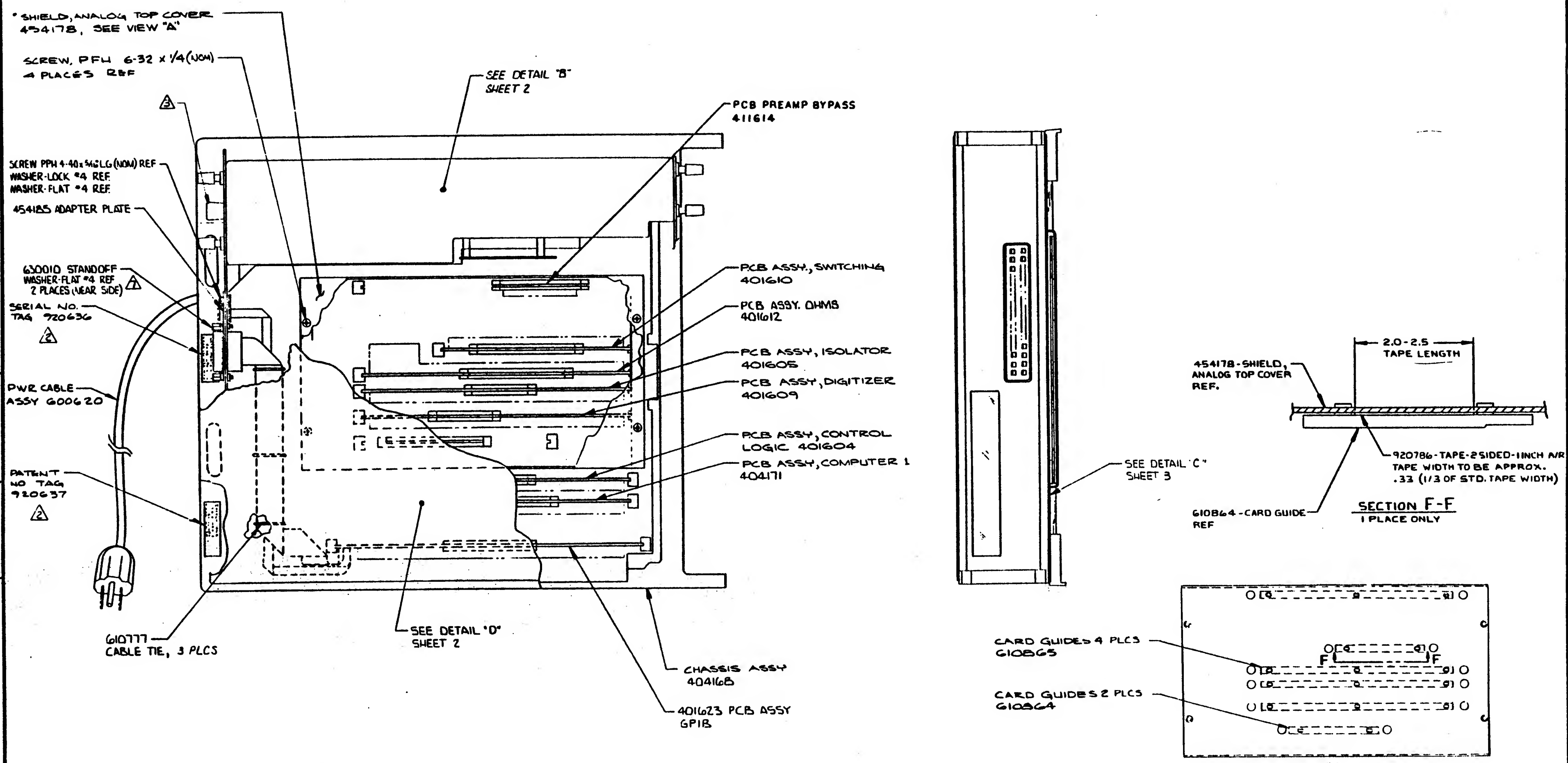
2. TAG & IDENTIFY WITH RACAL-DANA P/N & CURRENT REV. LTR.

1. ASSEMBLE PER RACAL-DANA WORKMANSHIP MANUAL.

NOTES: UNLESS OTHERWISE SPECIFIED

REAR PANEL ASSY

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	404169	E
SCALE 1/1		SHEET 1 OF 7	



NOTES: UNLESS OTHERWISE SPECIFIED

1. ASSEMBLE PER RACAL-DANA WORKMANSHIP MANUAL.

2. TYPE PERTINENT DATA ON SERIAL NUMBER LABEL, ATTACH SERIAL AND PATENT NUMBER LABELS TO BOTTOM FRAME APPROX AS SHOWN.

3. AFTER INSTALLATION OF CAL MODULE ASSEMBLY SECURE LATCH ON REAR PANEL TO BASE PLATE.

4. REMOVE PROTECTIVE BACKING FROM THE FOAM PADS AND THE ROUND AND RECTANGULAR BUMPERS AND ATTACH TO INSIDE OF TOP COVER. SEE DETAIL "D".

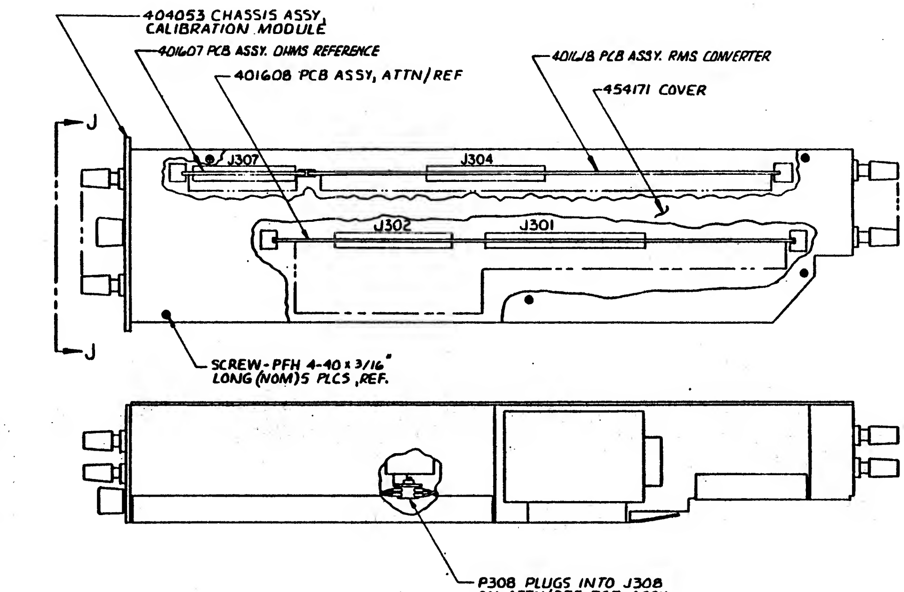
5. HOUSING TABS TO BE BENT FLAT AGAINST INSIDE OF BOTTOM COVER.

6. DISCARD NUTS AND LOCK WASHERS SUPPLIED WITH CONNECTOR.

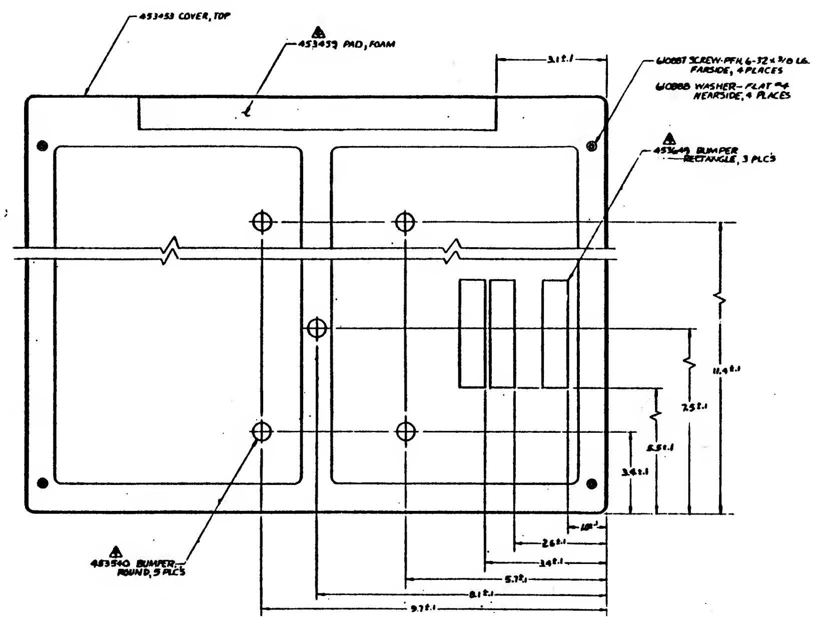
7. LABEL TO SHOW DVM MODEL NO., CAL MODULE S/N 4 OPTIONS WHICH ARE INSTALLED IN THE CAL MODULE. LABEL TO BE FLUSH WITH CORNERS OF REAR PANEL.

MICROPROCESSING DIGITAL MULTIMETER ASSY, 6002

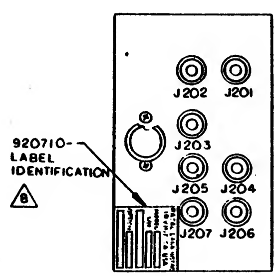
SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	404166	F
SCALE: NONE		SHEET 1 OF 6	



DETAIL B
SCALE: NONE



DETAIL D
SCALE: NONE

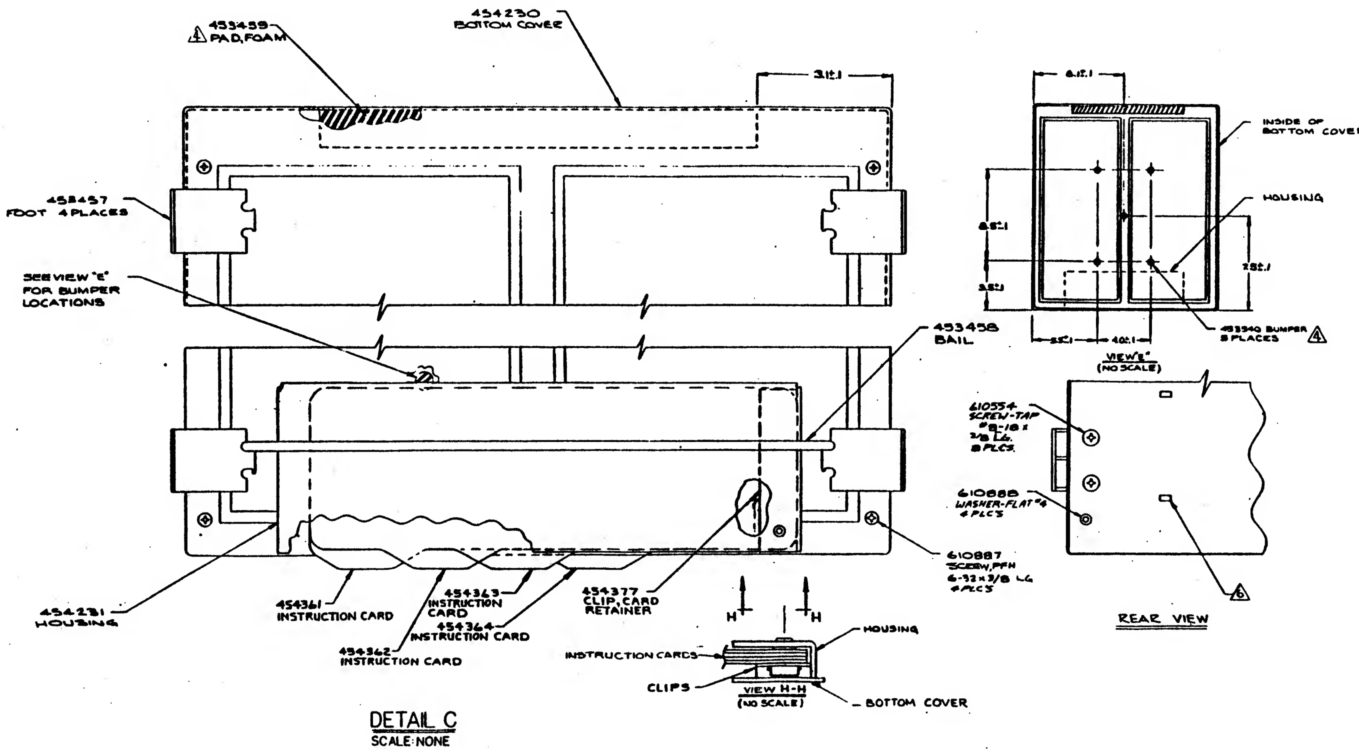


VIEW J
SCALE: NONE

NOTES: UNLESS OTHERWISE SPECIFIED

MICROPROCESSING DIGITAL MULTIMETER ASSY., 6002

SIZE	CODE IDENT NO	DWG NO.	REV
D	21793	404166	F
SCALE NONE		SHEET 2 OF 6	



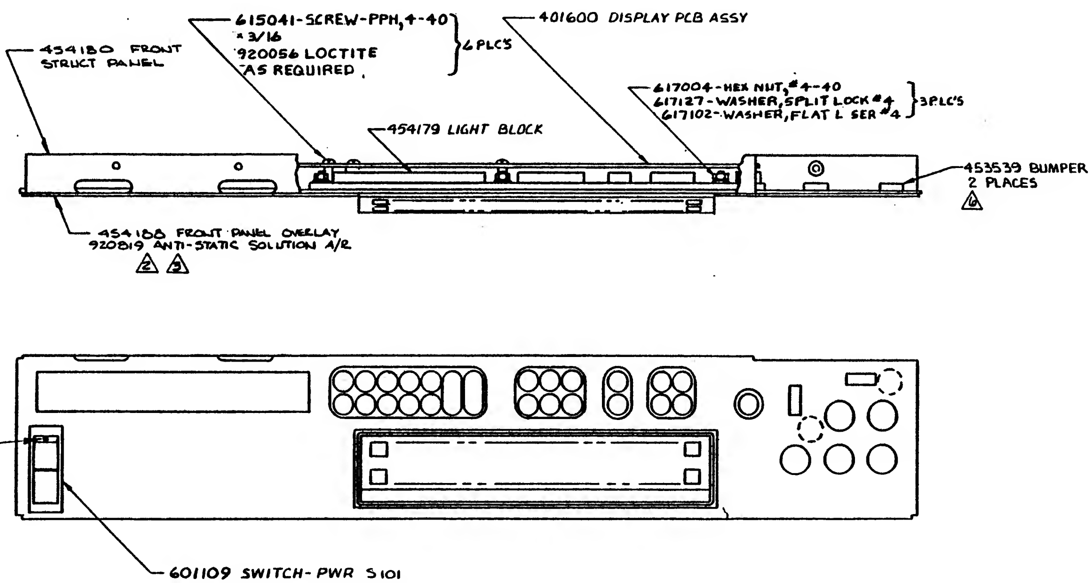
DETAIL C
SCALE: NONE

NOTES: UNLESS OTHERWISE SPECIFIED

MICROPROCESSING DIGITAL MULTIMETER ASSY., 6002

SIZE	CODE IDENT NO	DWG NO.	REV
D	21793	404166	F

SCALE: | SHEET 3 OF 6

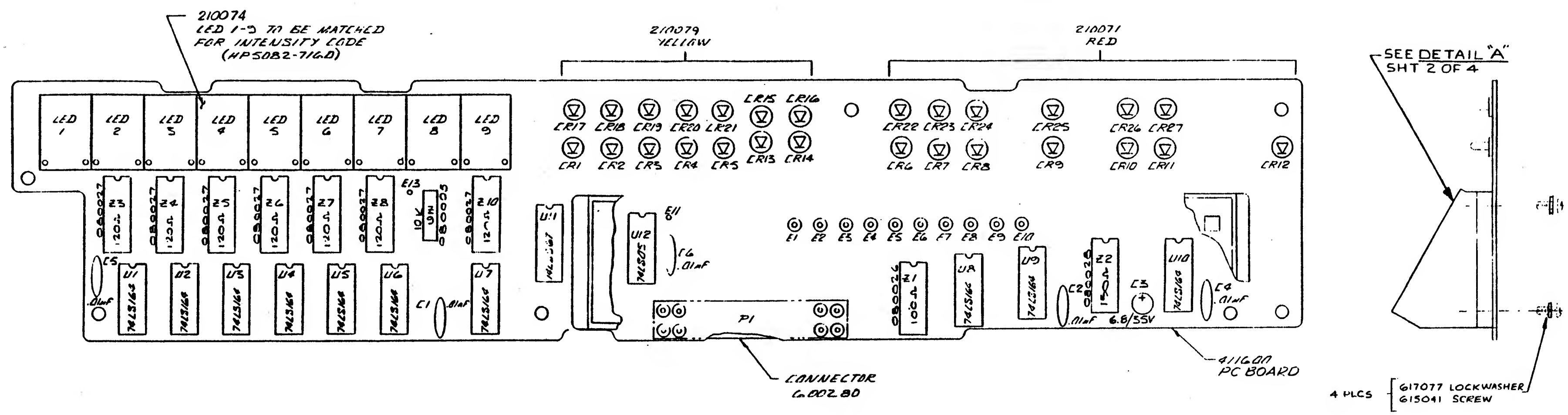


6. POSITION APPROX WHERE SHOWN.
5. TAG & IDENTIFY WITH DANA P/N & CURRENT REV. LTR.
4. COVER FOR PROTECTION DURING STORAGE & SHIPMENT.
3. APPLY ANTI-STATIC SOLUTION TO FRONT SIDE OF OVERLAY & WIPE CLEAN AFTER REMOVAL OF PROTECTIVE COVER & WHEN ASSEMBLY IS COMPLETE.
2. REMOVE PROTECTIVE PEEL-OFF COVER FROM OVERLAY & EXERCISE CAUTION DURING ASSEMBLY TO PREVENT DAMAGE TO FRONT SURFACE. ASSEMBLY TO BE FREE OF AIR BUBBLES.
1. ASSEMBLE PER DANA WORKMANSHIP MANUAL.

NOTES: UNLESS OTHERWISE SPECIFIED

FRONT PANEL ASSY

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	404011	E
SCALE 1:1		SHEET 1 OF 2	



2. ASSY PROCESSES & PROCEDURES TO CONFORM TO DANA WORKMANSHIP STANDARDS.
1 REF SCHEMATIC 431600

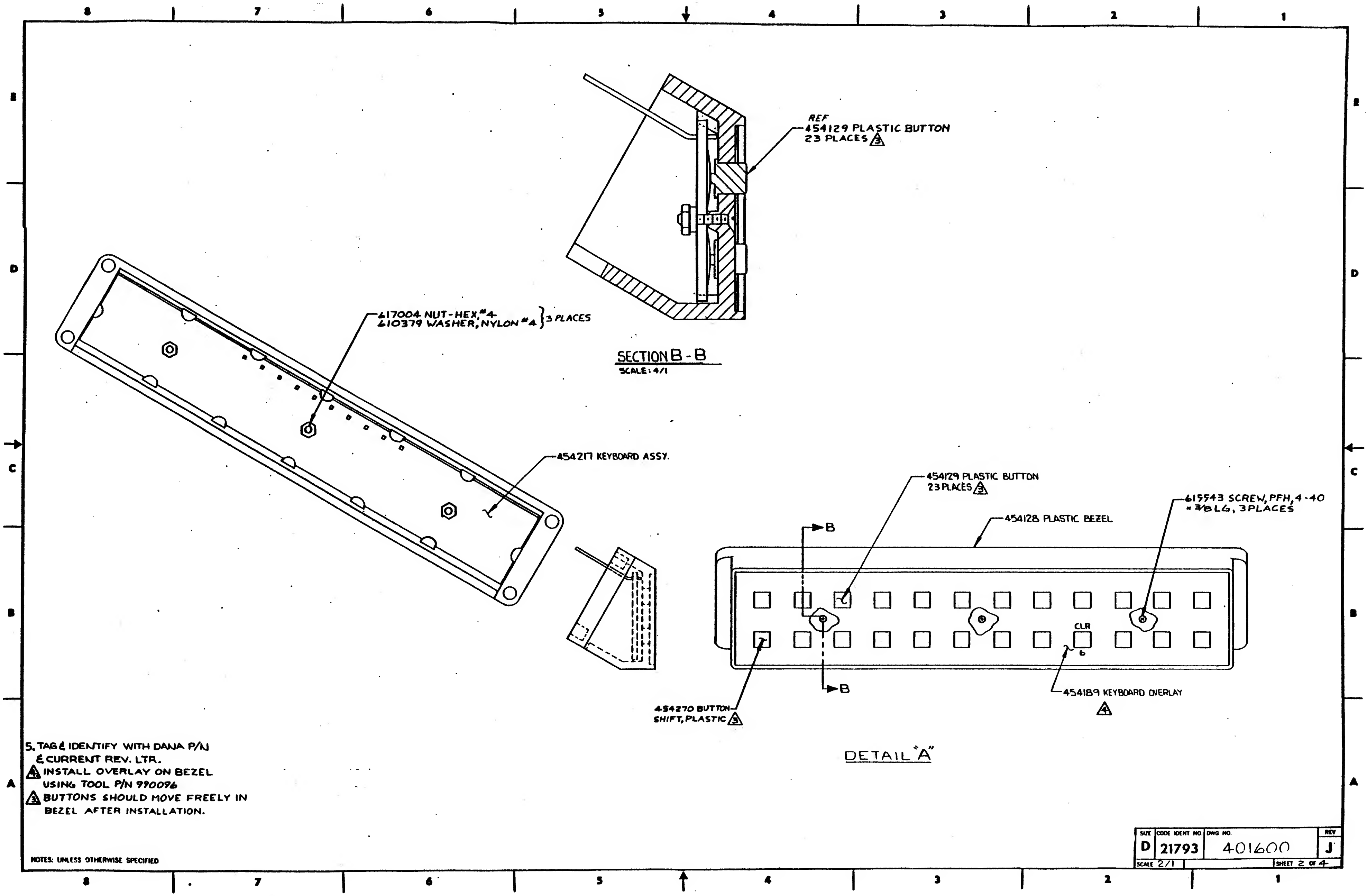
NOTES: UNLESS OTHERWISE SPECIFIED

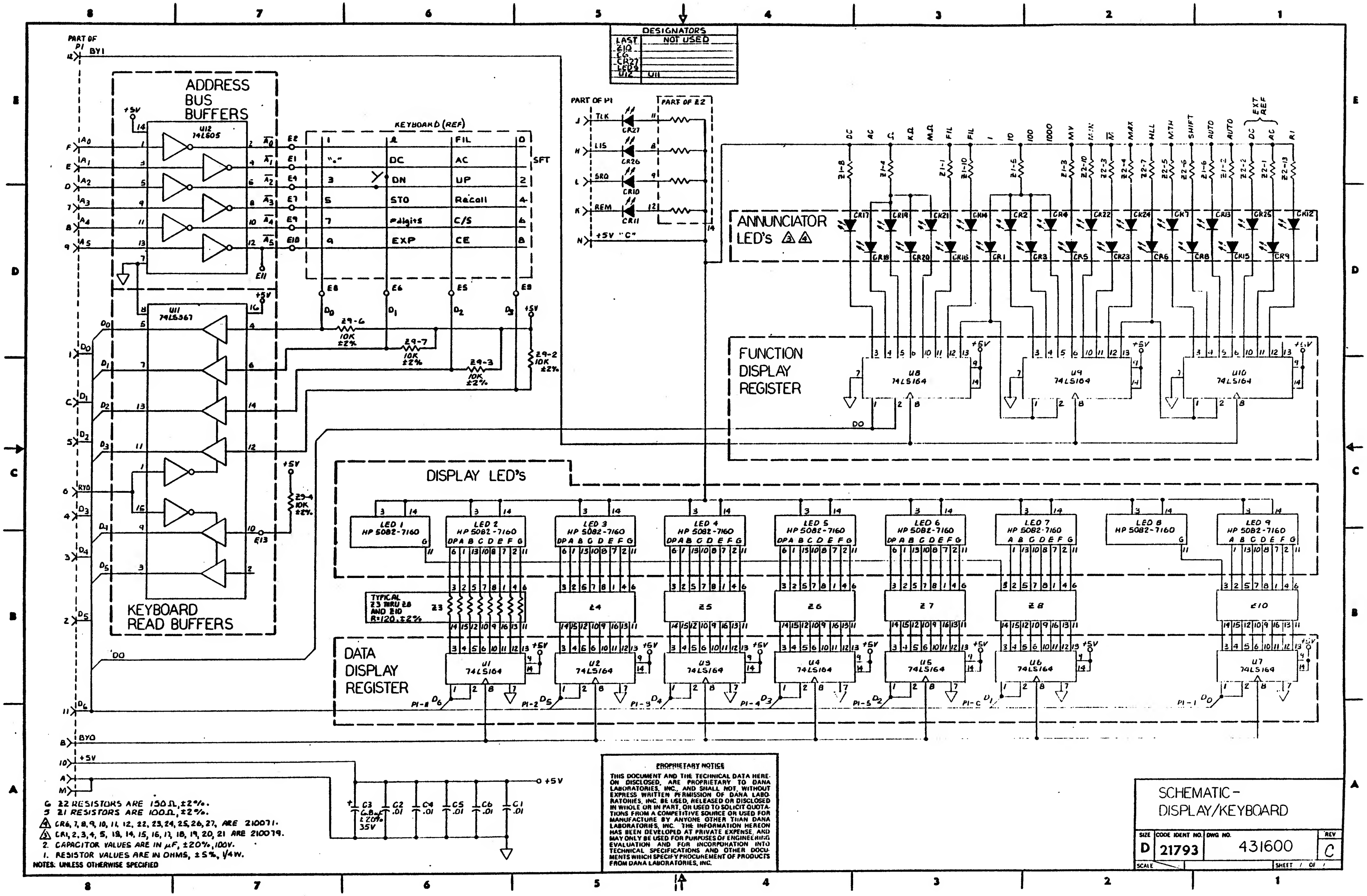
DANA LABORATORIES INC.
IRVINE, CALIFORNIA

ASSY
DISPLAY BOARD

SIZE	CODE IDENT NO	DWG NO.	REV
D	21793	431600	J

SCALE | SHEET 1 OF 4


REF
454129 PLASTIC BUTTON
23 PLACES 3
617004 NUT-HEX, #4
610379 WASHER, NYLON #4 } 3 PLACES
SECTION B - B
SCALE: 4/1
454217 KEYBOARD ASSY.
454129 PLASTIC BUTTON
23 PLACES 3
454128 PLASTIC BEZEL
615543 SCREW, PFH, 4-40
× 3/8 LG, 3 PLACES
B
B
CLR
454270 BUTTON-
SHIFT, PLASTIC 3
454189 KEYBOARD OVERLAY
4
DETAIL "A"
5. TAG & IDENTIFY WITH DANA P/N
& CURRENT REV. LTR.
4 INSTALL OVERLAY ON BEZEL
USING TOOL P/N 990096
3 BUTTONS SHOULD MOVE FREELY IN
BEZEL AFTER INSTALLATION.
NOTES: UNLESS OTHERWISE SPECIFIED
SIZE D
CODE IDENT NO 21793
DWG NO. 401600
REV J
SCALE 2/1
SHEET 2 OF 4


SCHEMATIC - DISPLAY/KEYBOARD
SIZE D
CODE IDENT NO. 21793
DWG NO. 431600
REV C
SCALE
SHEET 1 OF 1
DESIGNATORS
LAST | NOT USED
Z10
C6
CR27
LED9
U12 | U11
ADDRESS BUS BUFFERS
KEYBOARD READ BUFFERS
KEYBOARD (REF)
ANNUNCIATOR LED'S
FUNCTION DISPLAY REGISTER
DISPLAY LED'S
DATA DISPLAY REGISTER
TYPICAL Z3 THRU Z8 AND Z10 R=120, ±2%
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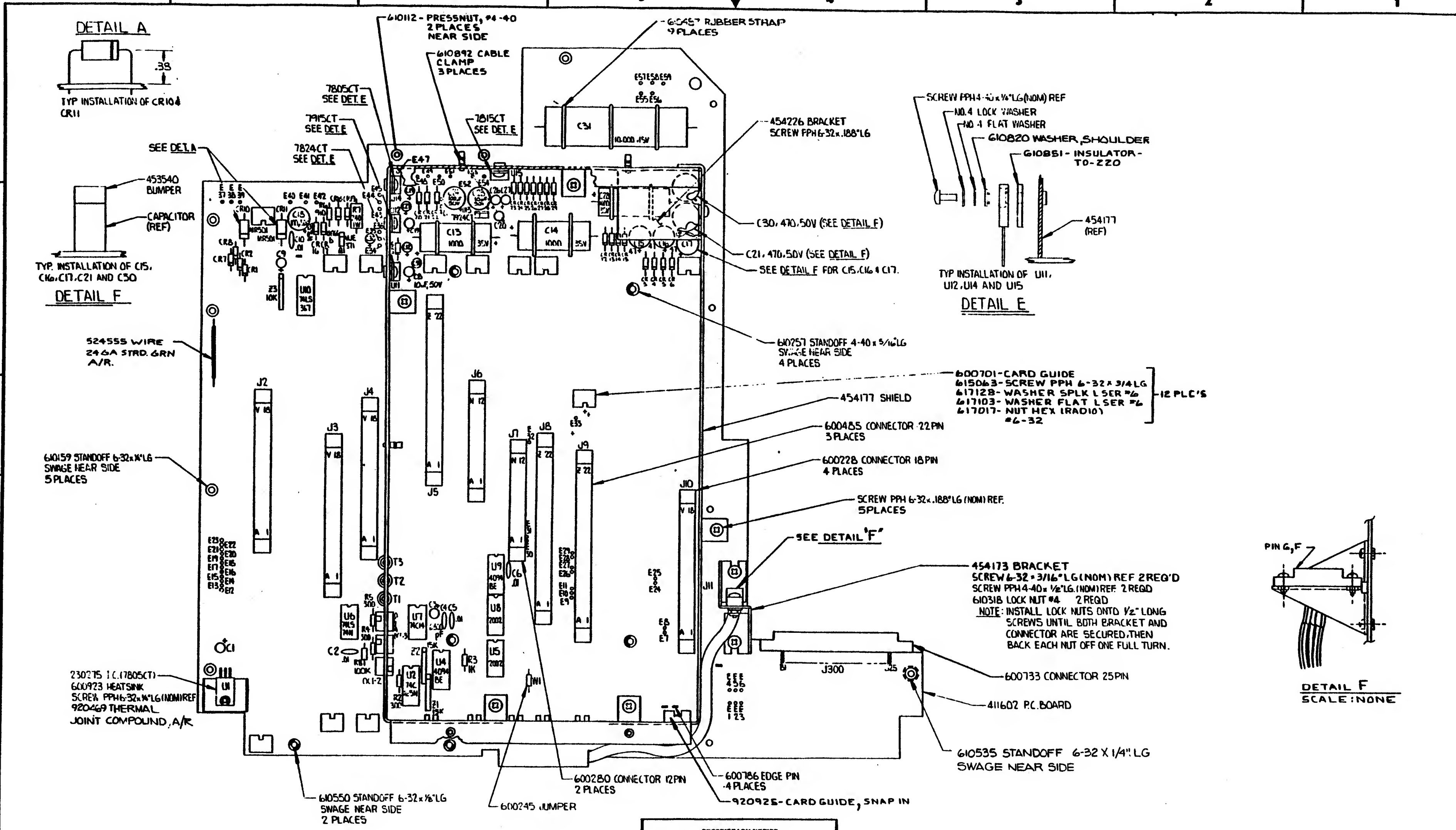
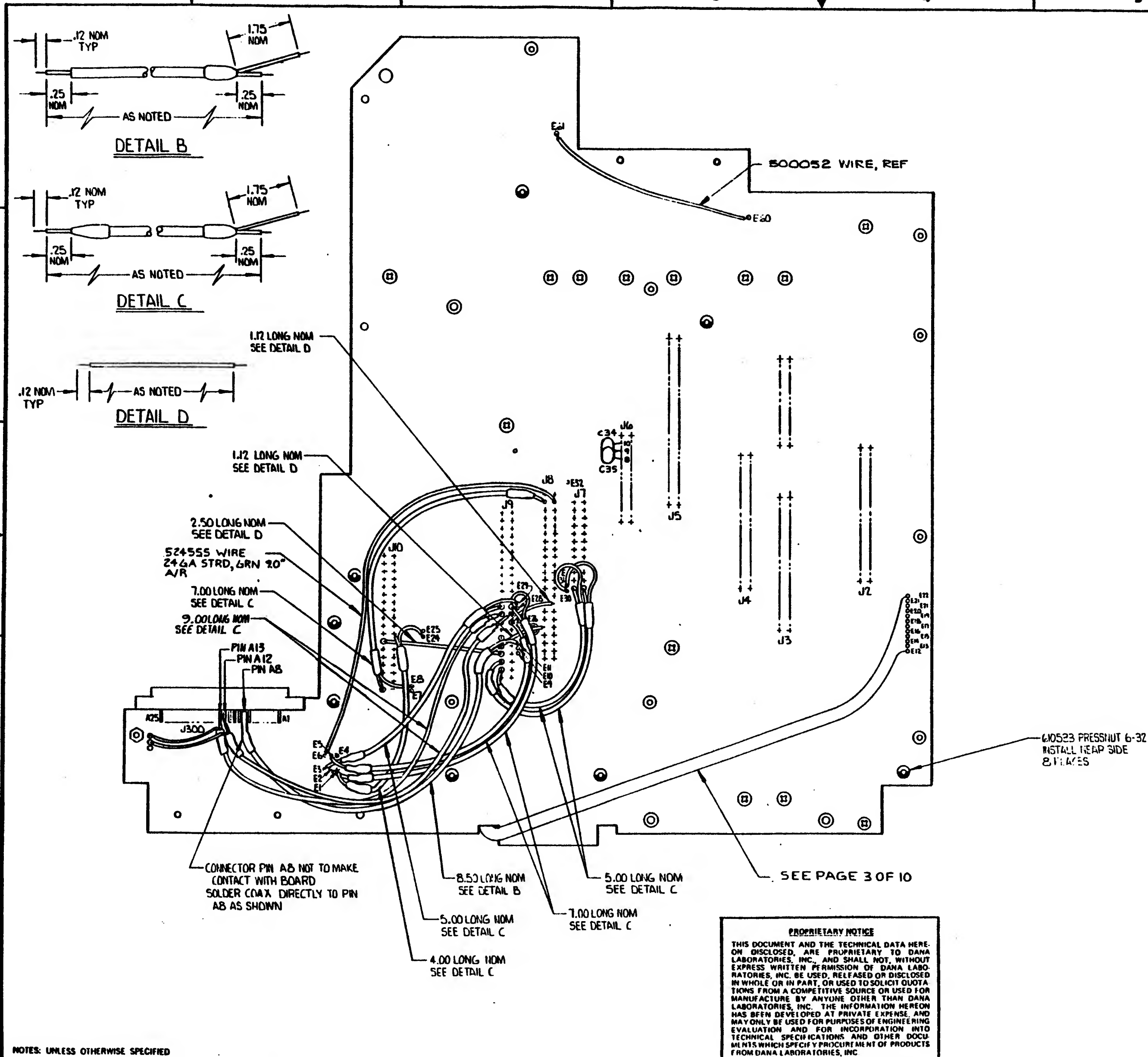
6 Z2 RESISTORS ARE 150Ω, ±2%.
5 Z1 RESISTORS ARE 100Ω, ±2%.
4 CR6, 7, 8, 9, 10, 11, 12, 22, 23, 24, 25, 26, 27, ARE 210071.
3 CR1, 2, 3, 4, 5, 13, 14, 15, 16, 17, 18, 19, 20, 21 ARE 210079.
2. CAPACITOR VALUES ARE IN µF, ±20%, 100V.
1. RESISTOR VALUES ARE IN OHMS, ±5%, 1/4W.
NOTES: UNLESS OTHERWISE SPECIFIED



5. CR1-9 & CR12-15, CR18-29 ARE IN4004 (SD-4)
4. C1, 3, 9, 12, 19, 20, 23, 26, 27, & 29 ARE 1/4, FD, 20% 35V
3. RESISTOR VALUES ARE IN OHMS, ±5%, ¼W.
2. SCHEMATIC REF 431602.
1. ASSEMBLY PROCEDURES AND PROCESSES TO CONFORM TO DANA WORKMANSHIP MANUAL.

NOTES: UNLESS OTHERWISE SPECIFIED

MOTHERBOARD ASSEMBLY			
SIZE: D	CODE IDENT NO: 21793	DWG NO: 401602	REV: Y
SCALE: 2/1		SHEET 1 OF 10	



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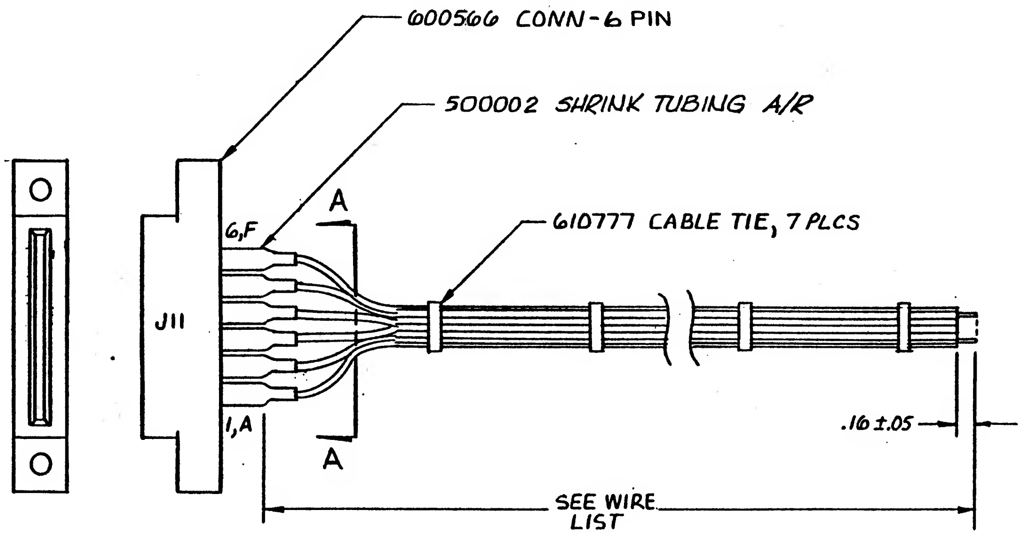
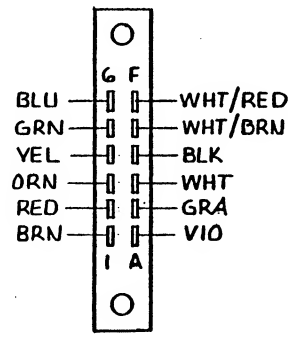
MOTHERBOARD ASSEMBLY

SIZE	CODE IDENT NO	DWG NO.	REV
D	21793	401602	Y
SCALE NONE		SHEET 2 OF 10	





VIEW A-A
SCALE 2/1

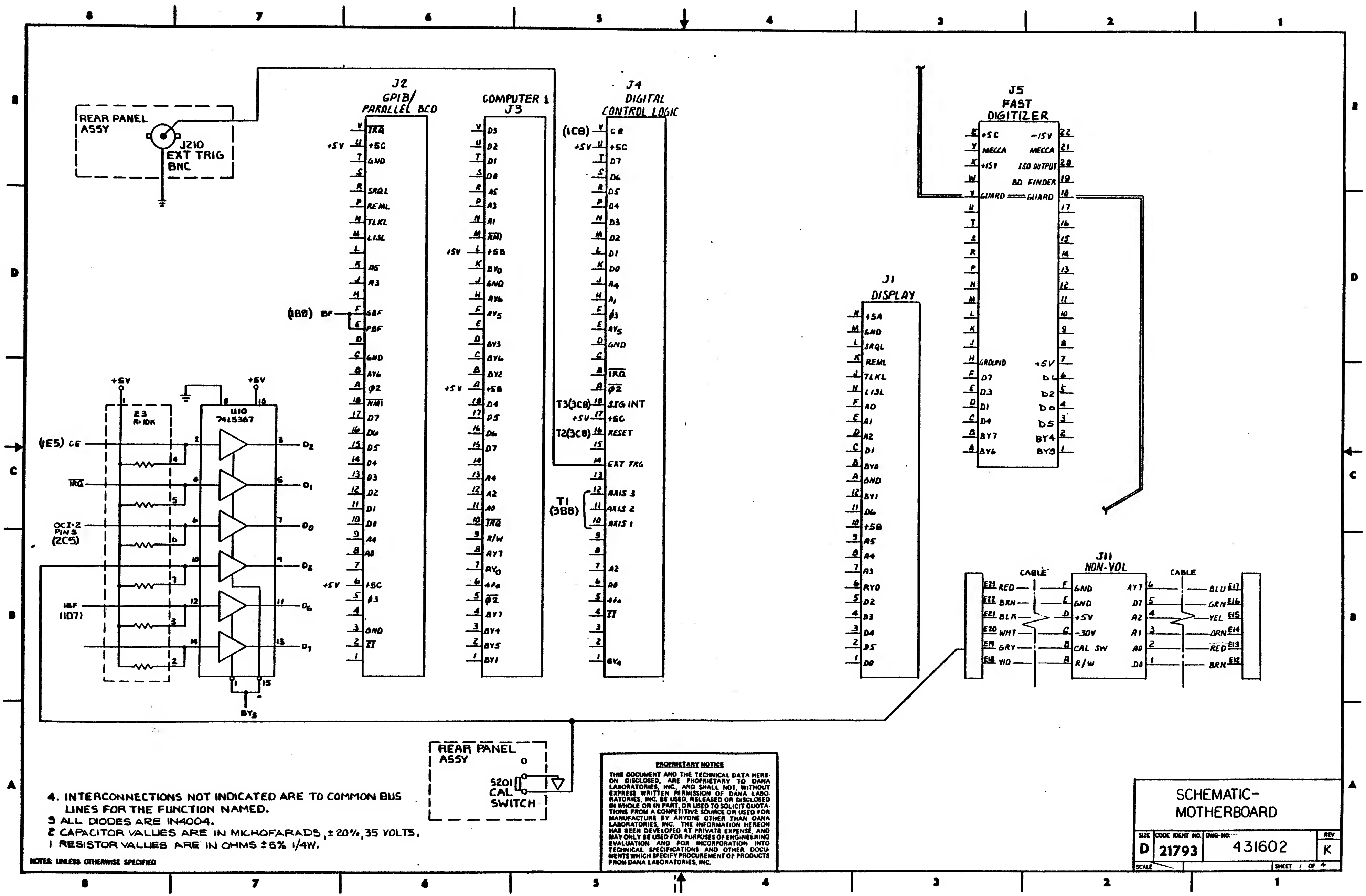
J11, PIN #	COLOR	PART NO.	LENGTH ±.15
F	WHT/RED	524929	18.5
E	WHT/BRN	524919	18.5
D	BLK	524000	18.5
C	WHT	524999	18.5
B	GRA	524888	18.5
A	VIO	524777	19.0
6	BLU	524666	19.0
5	GRN	524555	19.0
4	YEL	524444	19.0
3	ORN	524333	19.0
2	RED	524222	19.5
1	BRN	524111	19.5

WIRE LIST

NOTES: UNLESS OTHERWISE SPECIFIED

MOTHERBOARD ASSEMBLY

SIZE	CODE IDENT NO.	DWG NO.	REV
C	21793	401602	Y
SCALE		SHEET 10	


REAR PANEL
ASSY
J210
EXT TRIG
BNC
J2
GPIB/
PARALLEL BCD
COMPUTER 1
J3
J4
DIGITAL
CONTROL LOGIC
J1
DISPLAY
J5
FAST
DIGITIZER
J11
NON-VOL
CABLE
U10
74LS367
Z3
R=10K
REAR PANEL
ASSY
S201
CAL
SWITCH
4. INTERCONNECTIONS NOT INDICATED ARE TO COMMON BUS
LINES FOR THE FUNCTION NAMED.
3 ALL DIODES ARE IN4004.
2 CAPACITOR VALUES ARE IN MICROFARADS, ±20%, 35 VOLTS.
1 RESISTOR VALUES ARE IN OHMS ±5% 1/4W.
NOTES: UNLESS OTHERWISE SPECIFIED
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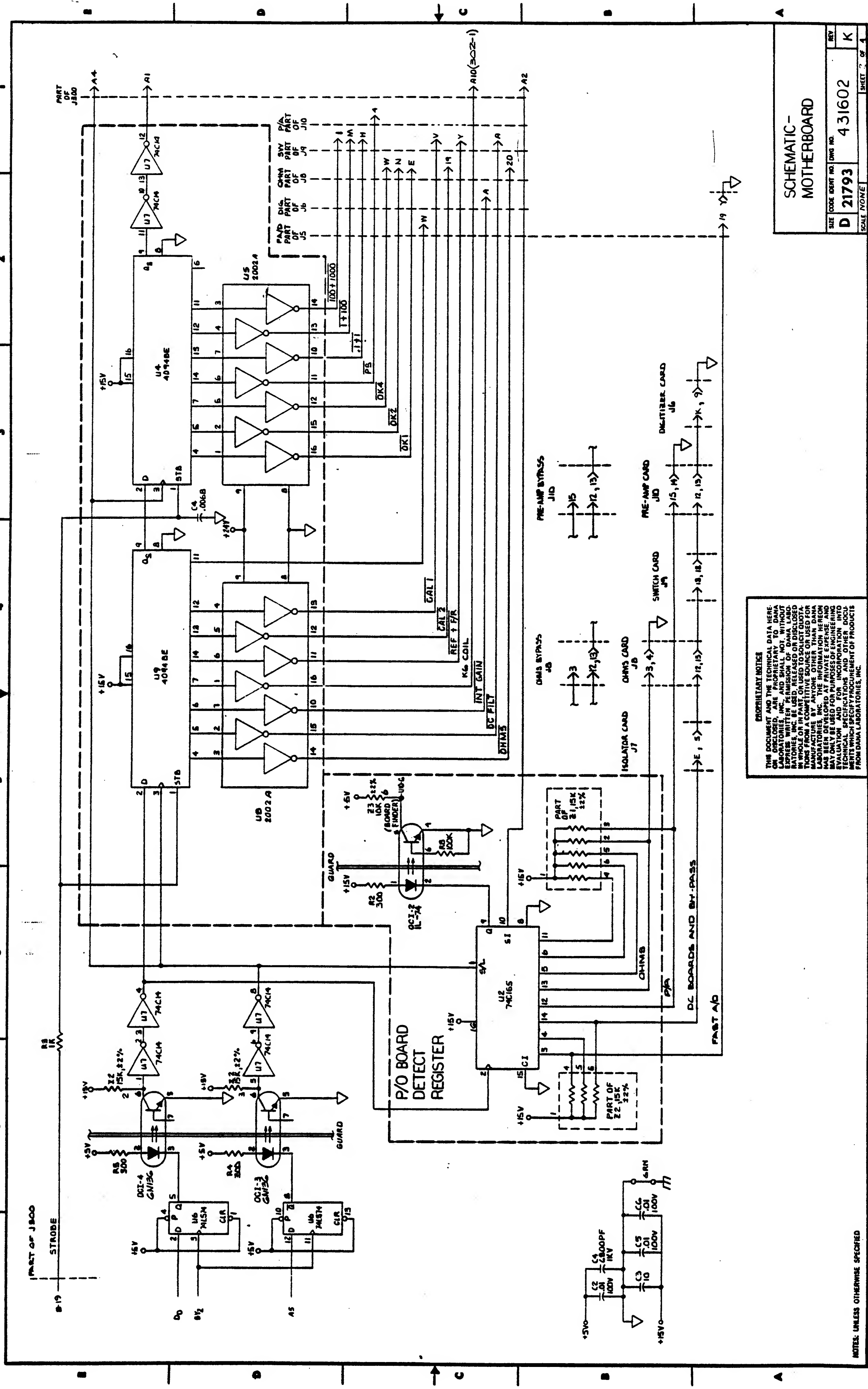
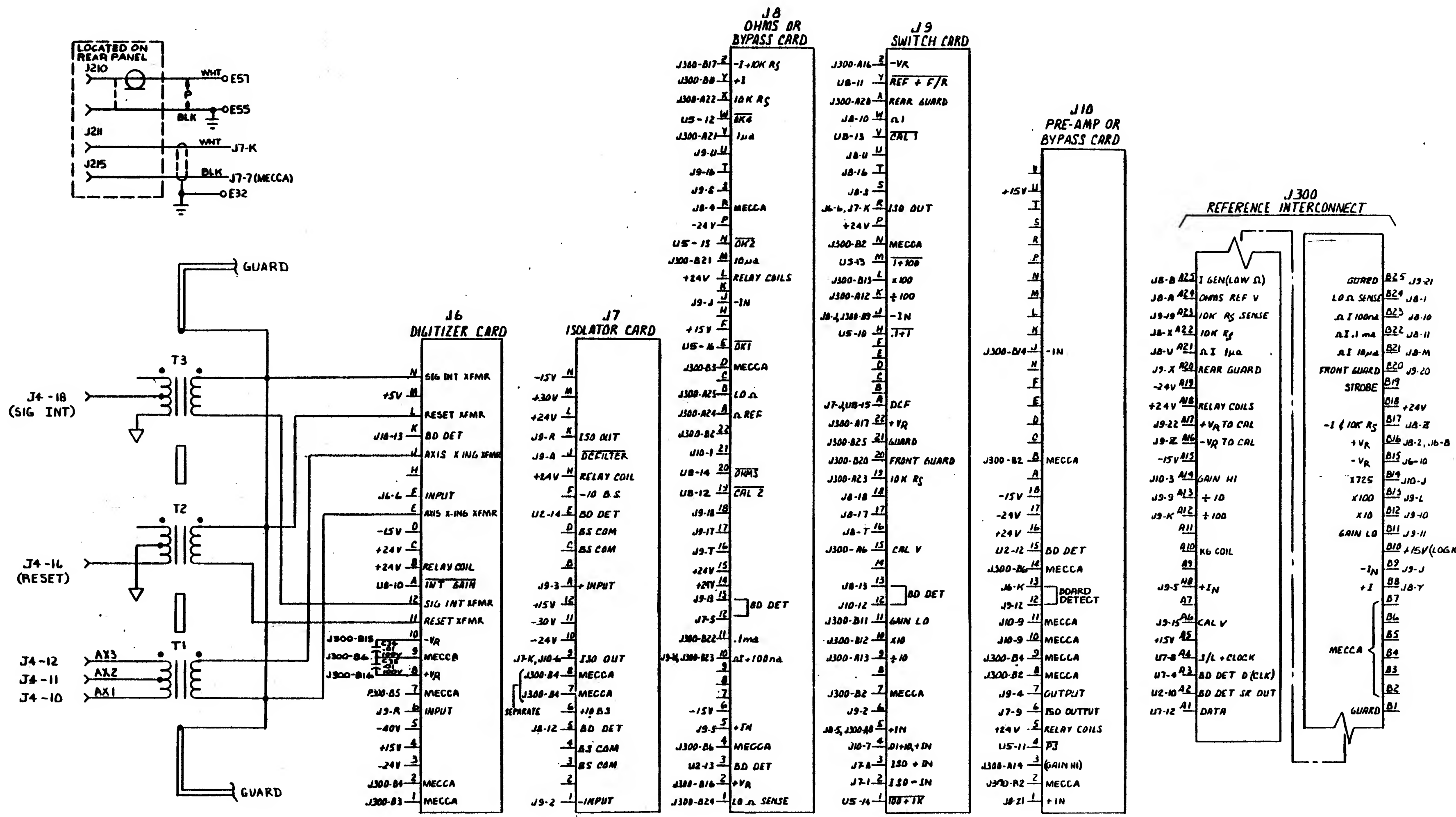
SCHEMATIC-
MOTHERBOARD
D
21793
431602
K


SCHEMATIC-
MOTHERBOARD
D
21793
431602
K
P/O BOARD
DETECT
REGISTER
NOTES: UNLESS OTHERWISE SPECIFIED



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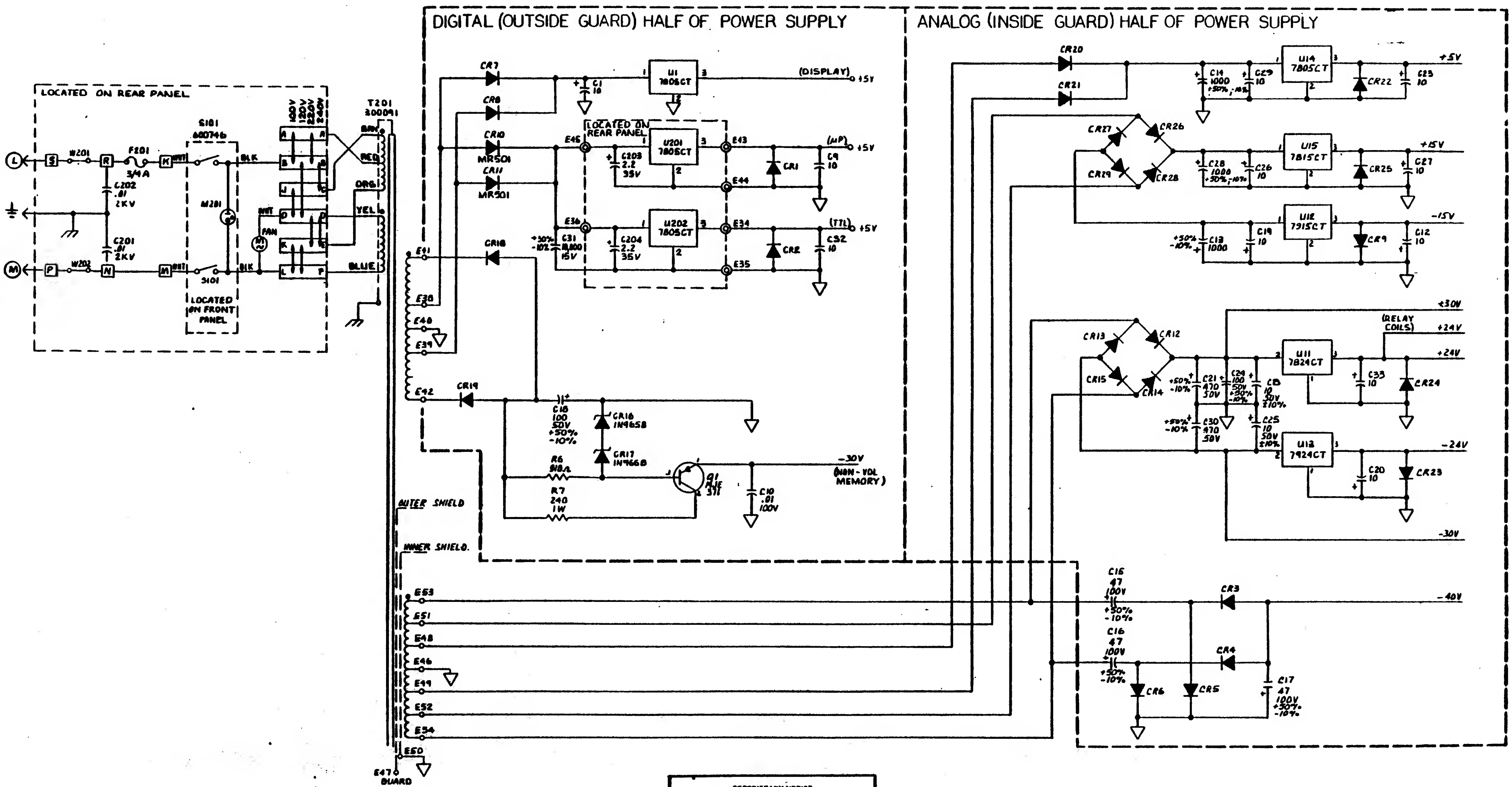
NOTES: UNLESS OTHERWISE SPECIFIED

SCHEMATIC- MOTHERBOARD			
SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	431602	K
SCALE		SHEET 3 OF 4	



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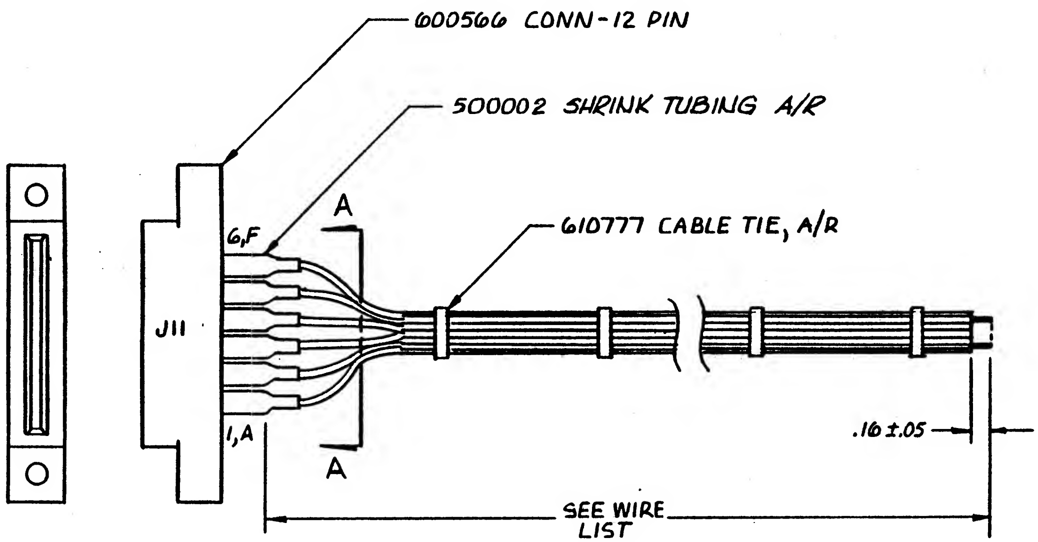
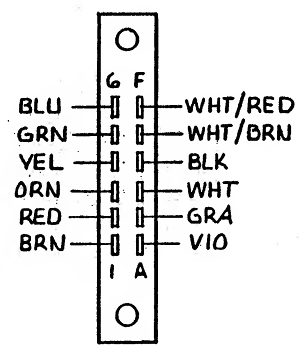
NOTES: UNLESS OTHERWISE SPECIFIED

SCHEMATIC - MOTHERBOARD

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	431602	K
SCALE		SHEET 4 OF 4	





VIEW A-A
SCALE 2/1

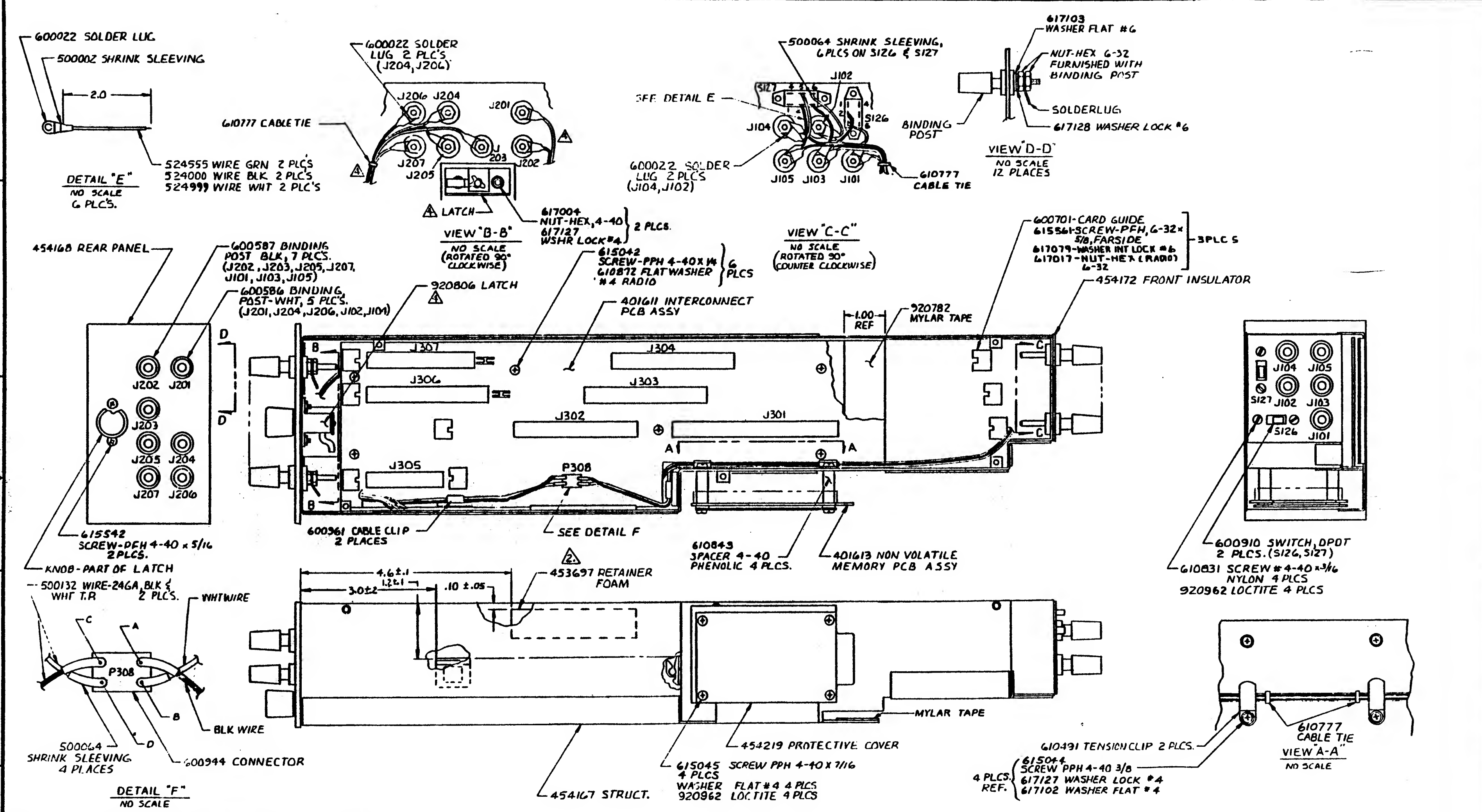
J11, PIN #	COLOR	PART NO.	LENGTH ±.15
F	WHT/RED	524929	18.5
E	WHT/BRN	524919	18.5
D	BLK	524000	18.5
C	WHT	524999	18.5
B	GRA	524888	18.5
A	VIO	524777	19.0
6	BLU	524666	19.0
5	GRN	524555	19.0
4	YEL	524444	19.0
3	ORN	524333	19.0
2	RED	524222	19.5
1	BRN	524111	19.5

WIRE LIST

2. TAG & IDENTIFY WITH DANA P/N & CURRENT REV. LTR.
1. ASSY PROCESSES & PROCEDURES TO CONFORM TO DANA WORKMANSHIP STDS.
NOTES: UNLESS OTHERWISE SPECIFIED

CABLE ASSY - NON-VOLATILE MEMORY

SIZE	CODE IDENT NO.	DWG NO.	REV
C	21793	404012	B
SCALE 2:1		SHEET 1 OF 2	



4. TO ELIMINATE INTERFERENCE ROUTE AND SECURE ALL INTERNAL WIRING AWAY FROM THE LATCH MECHANISM AND ITS THROW AREA.

3. IDENTIFY WITH RACAL-DANA P/N & CURRENT REV. LTR.

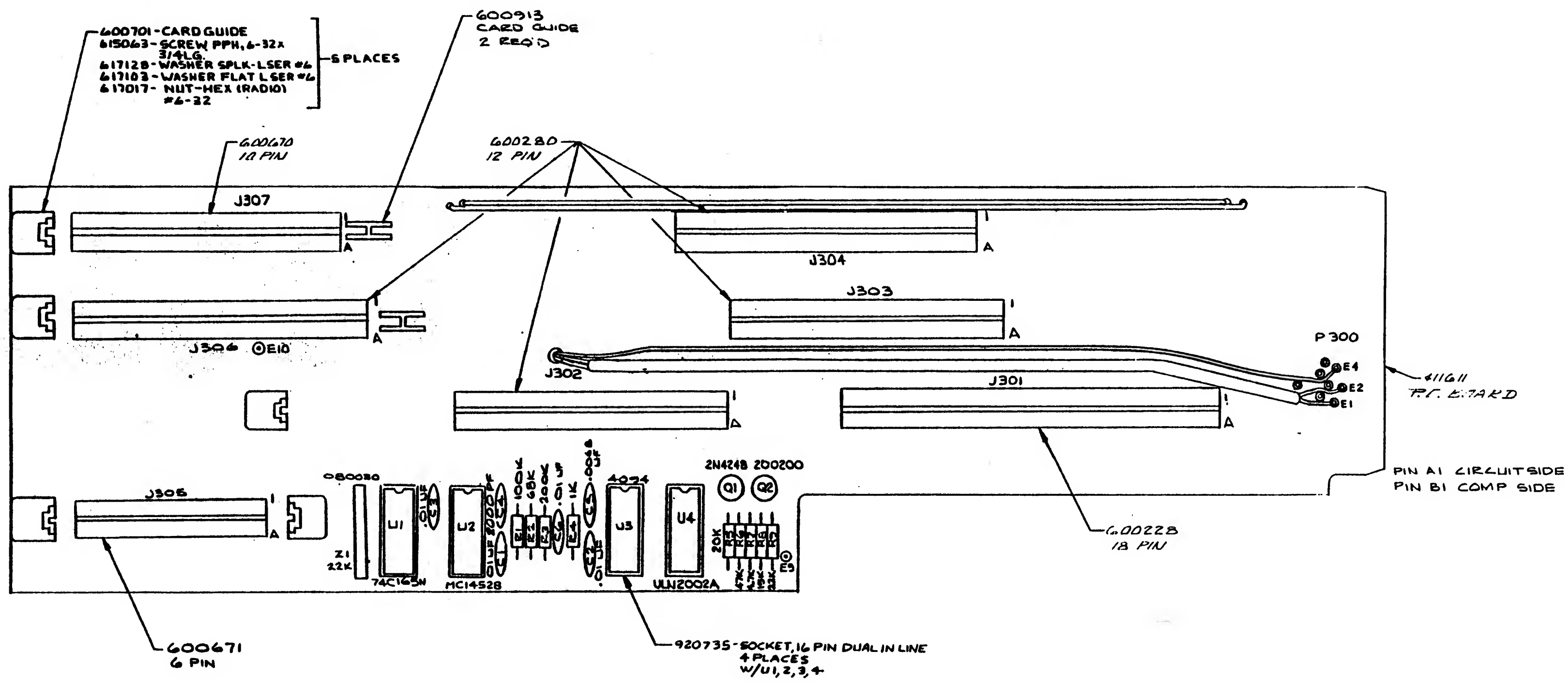
2. REMOVE PROTECTIVE BACKING FROM FOAM RETAINER AND ATTACH TO INSIDE OF CAL MODULE AS SHOWN.

1. ASSEMBLE PER DANA WORKMANSHIP MANUAL.

NOTES: UNLESS OTHERWISE SPECIFIED

CHASSIS ASSY– CALIBRATION MODULE

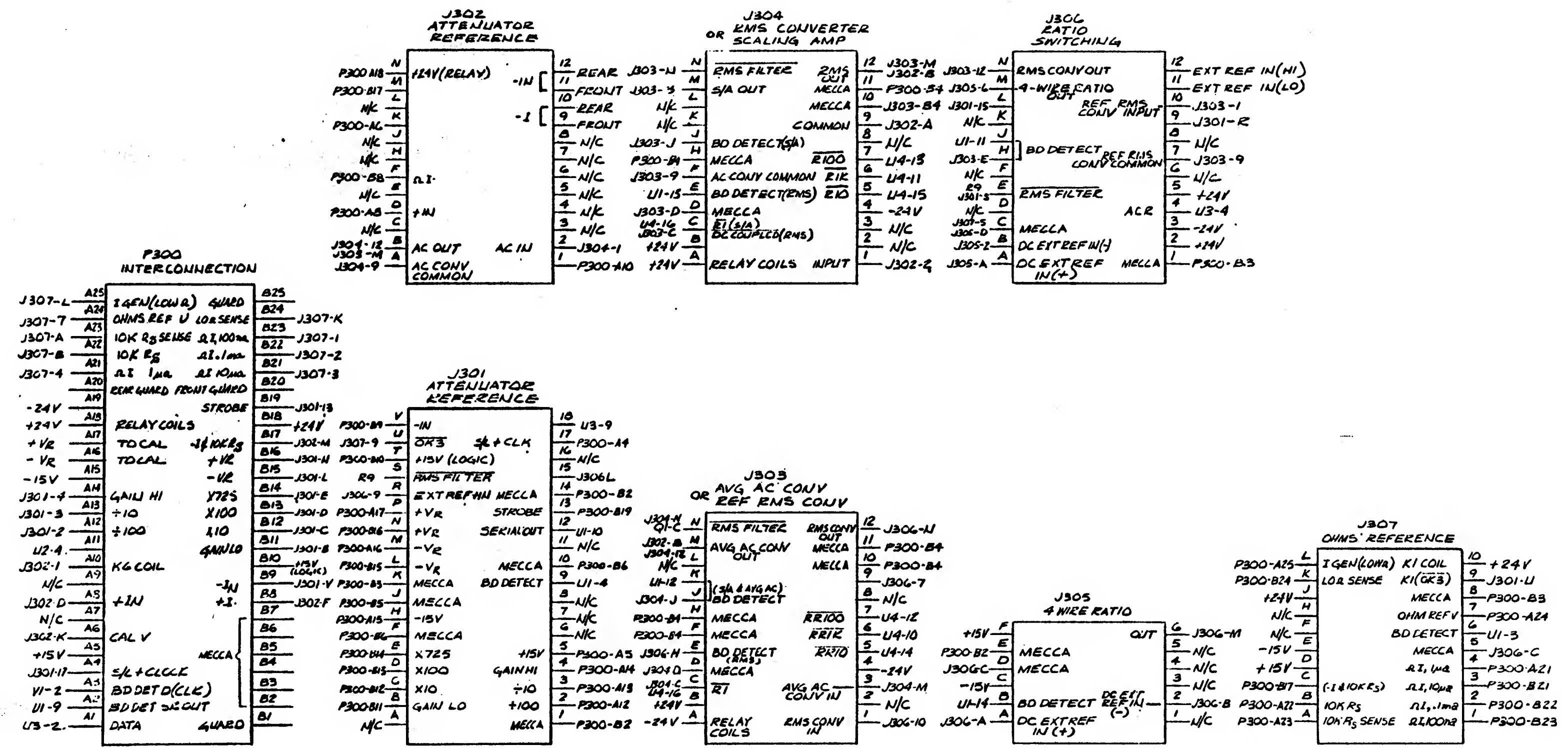
SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	404053	J
SCALE 1/1		SHEET 1 OF 5	



2. REF SCHEMATIC NO. 431611.
1. ASSY PROCESSES & PROCEDURES TO CONFORM TO DANA WORKMANSHIP STANDARDS.
NOTES: UNLESS OTHERWISE SPECIFIED

P.C.B. ASSY INTERCONNECTION

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	401611	R
SCALE 2X1.		SHEET 1 OF 4	



NOTES: UNLESS OTHERWISE SPECIFIED

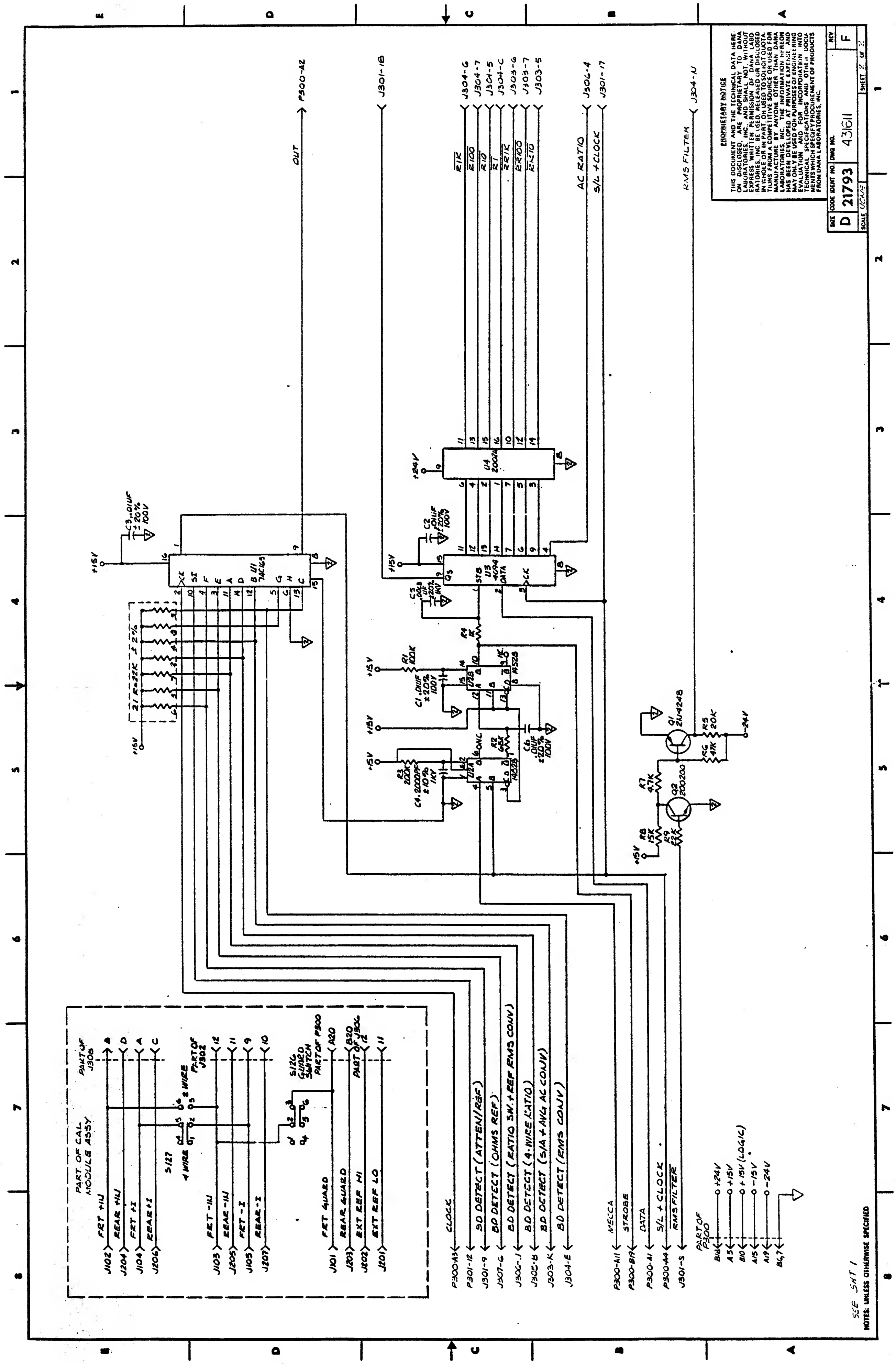
1 RESISTORS ARE IN OHMS, 1/4W ±5%

LAST	NOT USED
Z1	
Q2	
U4	
R9	
C6	
DESIGNATORS	

SCHEMATIC-INTERCONNECT,

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	431611	F

SCALE | SHEET 1 OF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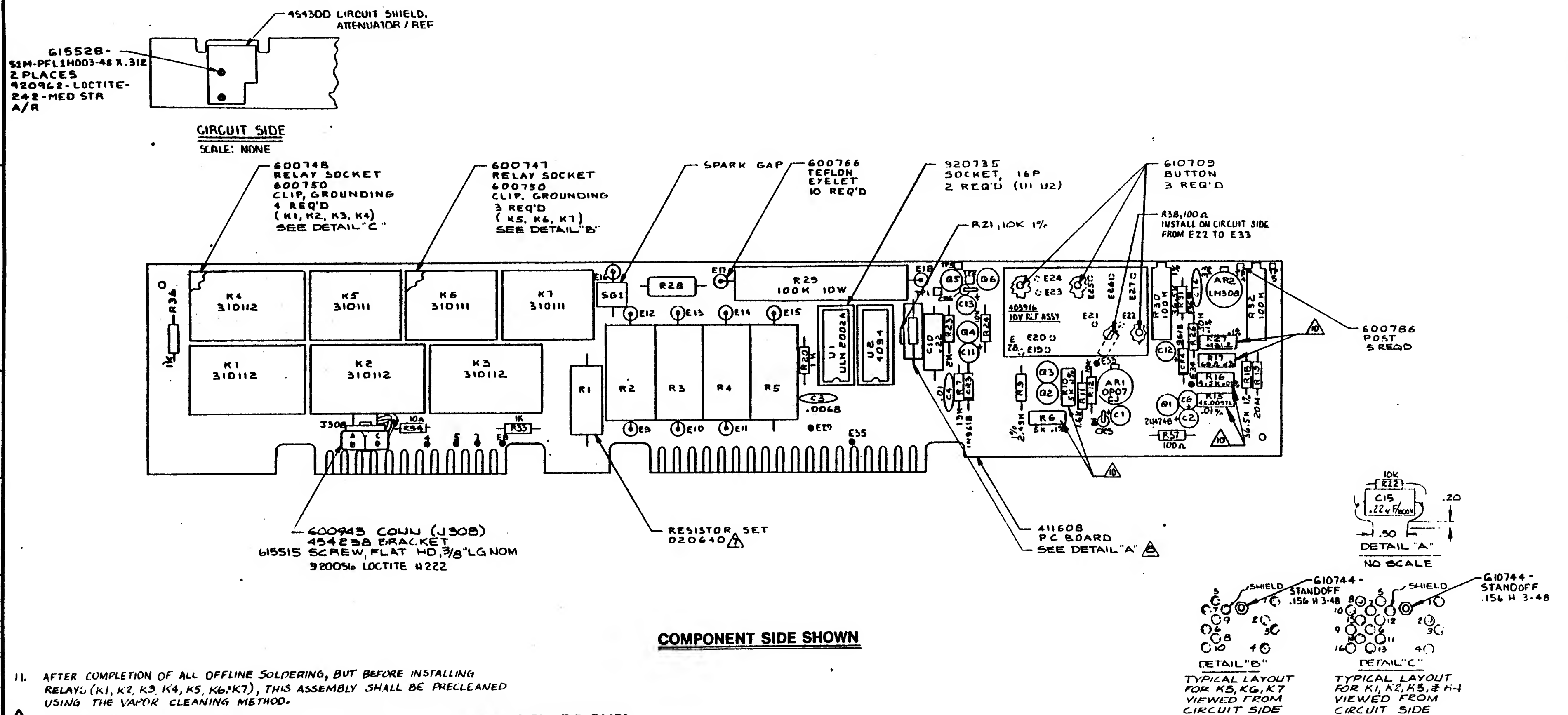
SIZE D
CODE IDENT NO. 21793
DWG NO. 431611
REV F
SCALE NONE
SHEET 2 OF 2
NOTES: UNLESS OTHERWISE SPECIFIED
SEE SHT 1
PART OF CAL MODULE ASSY
J102 FRT +HI
J204 REAR +HI
J104 FRT +I
J206 REAR +I
J103 FRT -HI
J205 REAR -HI
J105 FRT -I
J207 REAR -I
J101 FRT GUARD
J203 REAR GUARD
J202 EXT REF HI
J201 EXT REF LO
S127 4 WIRE
2 WIRE
S126 GUARD SWITCH PART OF P300
PART OF J308
PART OF J302
PART OF J306
P300-A3 CLOCK
P301-12 BD DETECT (ATTEN/REF)
J301-9 BD DETECT (OHMS REF)
J307-G BD DETECT (RATIO SW.+REF RMS CONV)
J306-J BD DETECT (4-WIRE RATIO)
J302-B BD DETECT (S/A+AVG AC CONV)
J303-K BD DETECT (RMS CONV)
J304-E BD DETECT (RMS CONV)
P300-A11 MECCA
P300-B19 STROBE
P300-A1 DATA
P300-A4 S/L+CLOCK
J301-S RMS FILTER
PART OF P300
B18 +24V
A5 +15V
B10 +15V (LOGIC)
A15 -15V
A19 -24V
B6,7
OUT P300-A2
J301-18
R1K J304-G
R100 J304-7
R10 J301-5
RT J304-C
RR1K J303-G
RR100 J303-7
RR10 J303-5
AC RATIO J306-4
S/L+CLOCK J301-17
RMS FILTER J304-N
U1 74C165
U2 14528
U3 4094
U4 2002A
Q1 2N4248
Q2 200200
21 R=22K ±2%
C1 .01UF ±20% 100V
C2 .01UF ±20% 100V
C3 .01UF ±20% 100V
C4 .002UF ±10% 1KV
C5 .01UF ±20% 1KV
C6 .01UF ±20% 100V
R1 100K
R2 68K
R3 200K
R4 1K
R5 20K
R6 47K
R7 4.7K
R8 15K
R9 22K
+15V
+24V
-24V



COMPONENT SIDE SHOWN

11. AFTER COMPLETION OF ALL OFFLINE SOLDERING, BUT BEFORE INSTALLING RELAYS (K1, K2, K3, K4, K5, K6, K7), THIS ASSEMBLY SHALL BE PRECLEANED USING THE VAPOR CLEANING METHOD.

10. THE FOLLOWING DEVICES ARE TO BE INSTALLED OFFLINE AND ARE NOT TO BE EXPOSED TO THE WAVE SOLDER PROCESS: (P/N 010770) R15, (P/N 010769) R16, (P/N 012037) R17, (P/N 012051) R27, (P/N 010871) R6, & (P/N 010871) R10.

9. WIRES TO BE AS SHORT AS POSSIBLE AND INSTALLED AS CLOSE AS POSSIBLE TO P.C. BOARD TO CLEAR CIRCUIT SHIELD. SLEEVE ALL CONNECTIONS USING 500063-TBGSRK----.093ID.

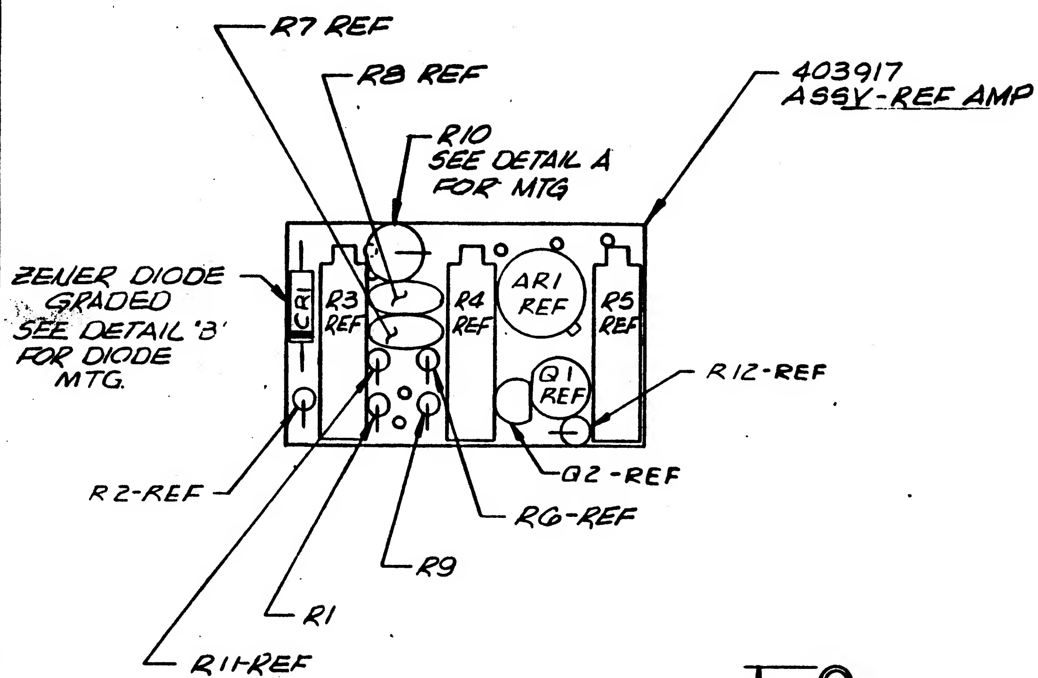
8. INSTALL C15 INTO HOLES SILKSCREENED R22

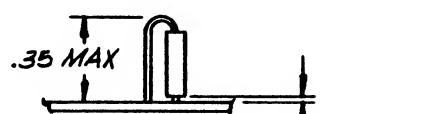
7. RESISTOR SET TO CONSIST OF R1 899.45K, R2, 3, 4, 5 22499M, R28 99.950K

6. ALL CAPACITORS ARE IN MFD
5. RESISTORS ARE ±5% 1/4 W
4. TRANSISTORS Q2 THRU Q6 ARE 200200
3. CAPACITORS C1, 2, 6, 11, 12, 13 ARE 110126
2. REFERENCE SCHEMATIC NO. 431608
1. ASSEMBLY PROCESSES & PROCEDURES TO CONFORM TO DANA WORKMANSHIP STANDARDS

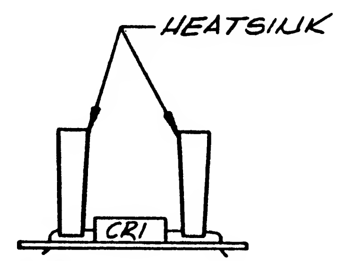
NOTES: UNLESS OTHERWISE SPECIFIED

DANA	DANA LABORATORIES INC. IRVINE, CALIFORNIA		
P.C. BOARD ASSY ATTENUATOR REF			
SIZE D	CODE IDENT NO. 21793	DWG NO. 401608	REV AA
SCALE 2/1		SHEET 1 OF 7	





DETAIL A
TYP FOR R1, R9, R10

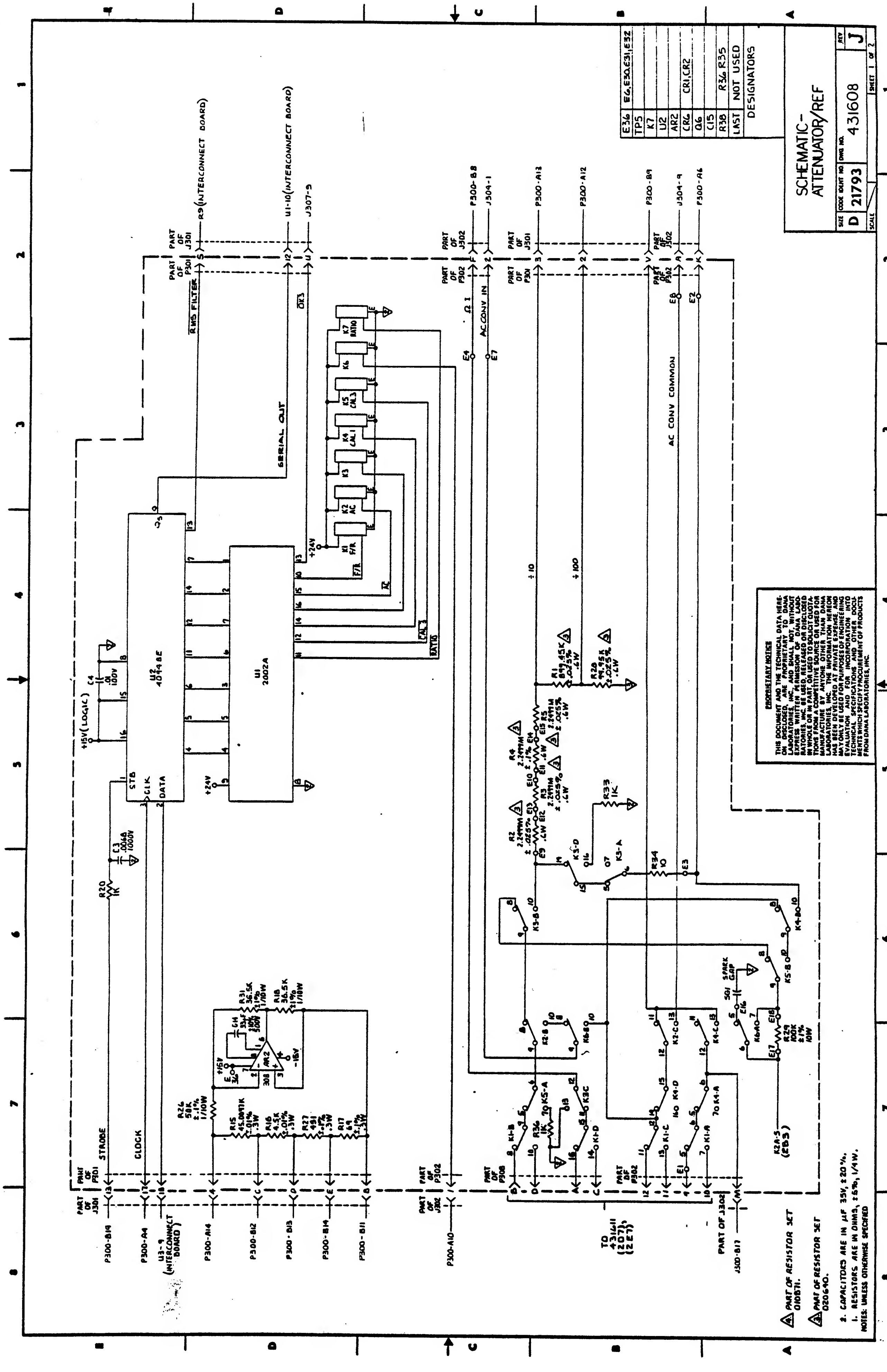


DETAIL B
HEATSINK DIODE LEADS WHILE SOLDERING

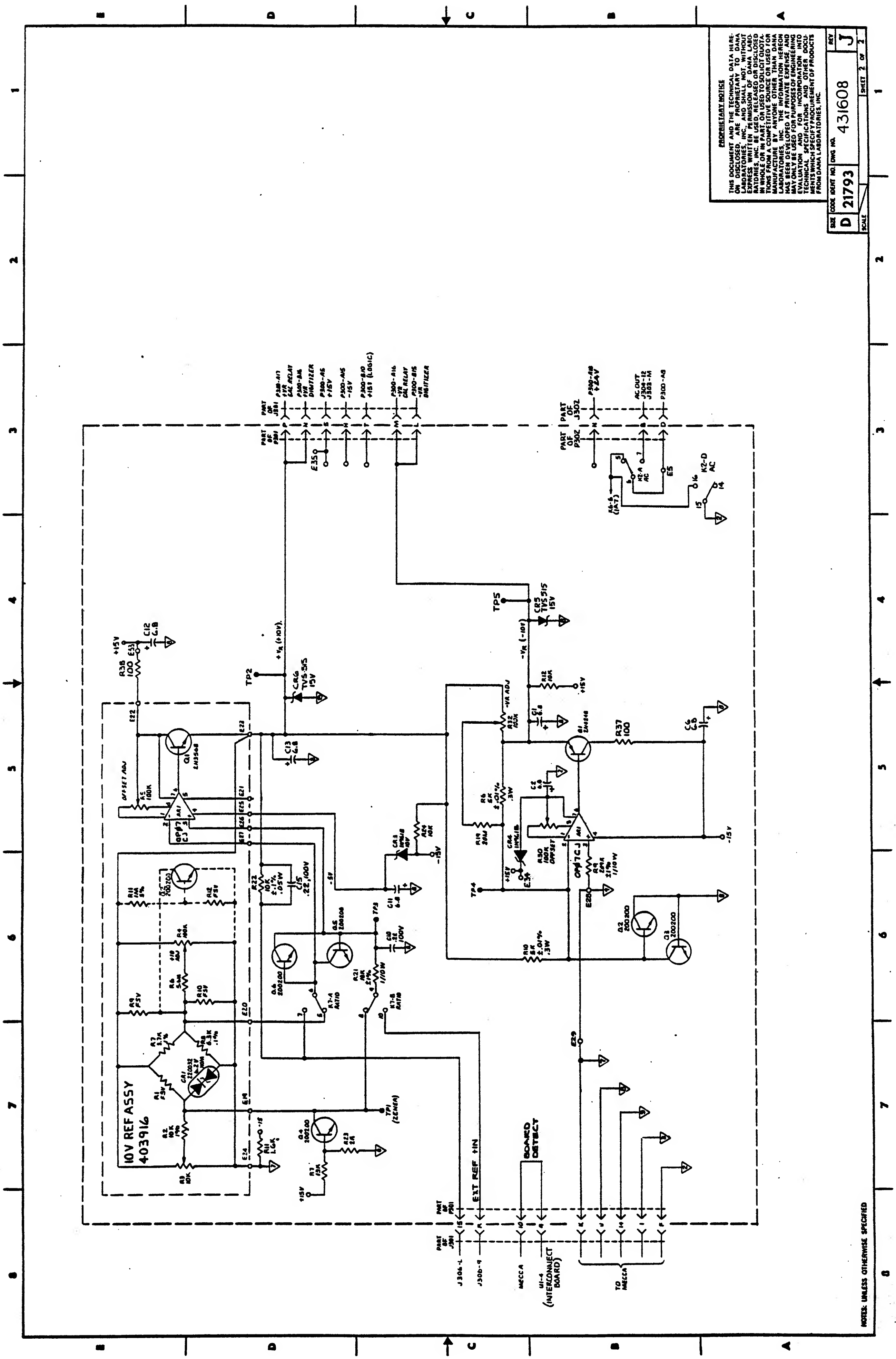
3. ALL COMPONENTS TO BE .35 MAX. ABOVE PCB
2. SCHEMATIC REF 432008
1. ASSY PROCESSES & PROCEDURES TO CONFORM TO DANA WORKMANSHIP STDS

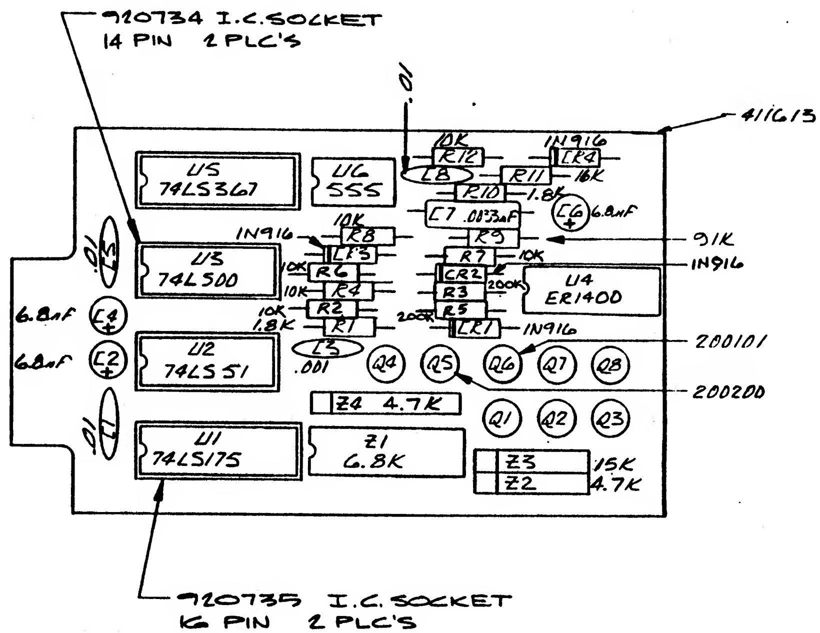
NOTES: UNLESS OTHERWISE SPECIFIED

ASSY PCB, 10 V REFERENCE			
SIZE B	CODE IDENT NO. 21793	DWG NO. 403916	REV E
SCALE 2/1		SHEET 1 OF 5	



SCHEMATIC-
ATTENUATOR/REF
SIZE D
CODE IDENT NO 21793
DWG NO 431608
REV J
SHEET 1 OF 2
E36 E6,E30,E31,E32
TP5
K7
U2
AR2
CR6 CR1,CR2
Q6
C15
R38 R36,R35
LAST NOT USED
DESIGNATORS
PROPRIETARY NOTICE
U2 4094BE
U1 2002A
SERIAL OUT
STROBE
CLOCK
AC CONV IN
AC CONV COMMON
RMS FILTER
K1 F/R
K2 AC
K3
K4 CAL 1
K5 CAL 3
K6
K7 RATIO
+15V (LOGIC)
+24V
SPARK GAP
R9 (INTERCONNECT BOARD)
U1-10 (INTERCONNECT BOARD)
J307-5
TO 431611 (2D7) (2E7)
PART OF J302
PART OF RESISTOR SET 010871.
PART OF RESISTOR SET 020640.
NOTES: UNLESS OTHERWISE SPECIFIED
1. RESISTORS ARE IN OHMS, ±5%, 1/4W.
2. CAPACITORS ARE IN µF 35V, ±20%.


10V REF ASSY
403916
BOARD DETECT
EXT REF +IN
TP2
TP4
TP5
PROPRIETARY NOTICE
D
21793
431608
J
NOTES: UNLESS OTHERWISE SPECIFIED

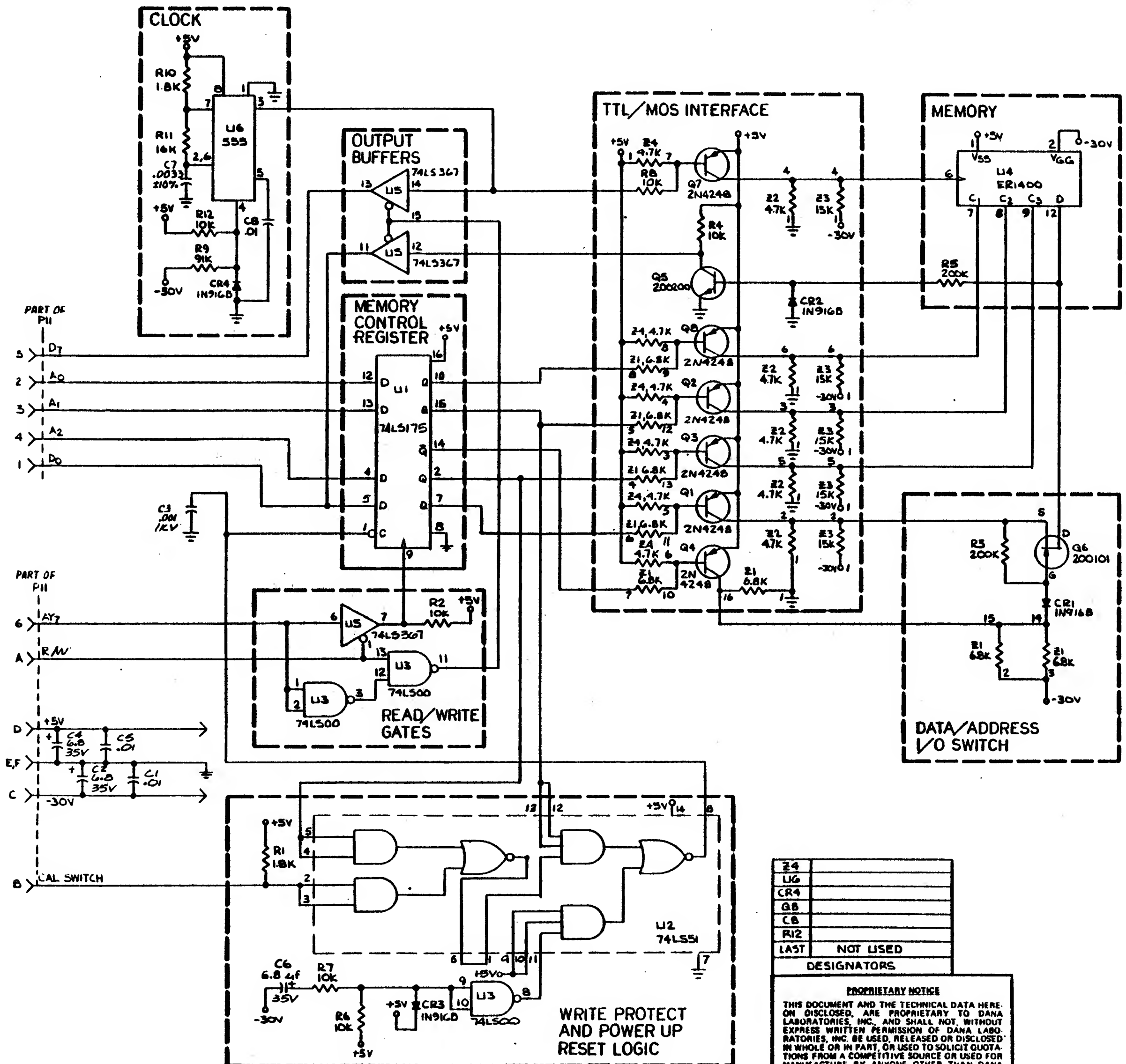


3. TRANSISTORS Q1 - 4, 7, 8 ARE NO. 2000BB.
2. REF. SCHEMATIC NO. 431613.
1. ASSY PROCESSES & PROCEDURES TO CONFORM TO DANA WORKMANSHIP STANDARDS.

NOTES: UNLESS OTHERWISE SPECIFIED

PCB ASSY
NON-VOLATILE
MEMORY

SIZE	CODE IDENT NO.	DWG NO.	REV
C	21793	401613	D
SCALE 2X1			1 OF 3



A_0	A_1	A_2	
0	0	0	STANDBY
0	1	1	ADDRESS
1	0	0	READ
1	0	1	DATA OUT
0	1	0	ERASE
1	1	1	DATA IN
1	1	0	WRITE
0	0	1	X

READ SEQUENCE
- ADDRESS
- READ
- DATA OUT

WRITE SEQUENCE
- ADDRESS
- ERASE
- DATA IN
- WRITE

LAST	NOT USED
Z4	
U6	
CR4	
Q8	
C8	
R12	

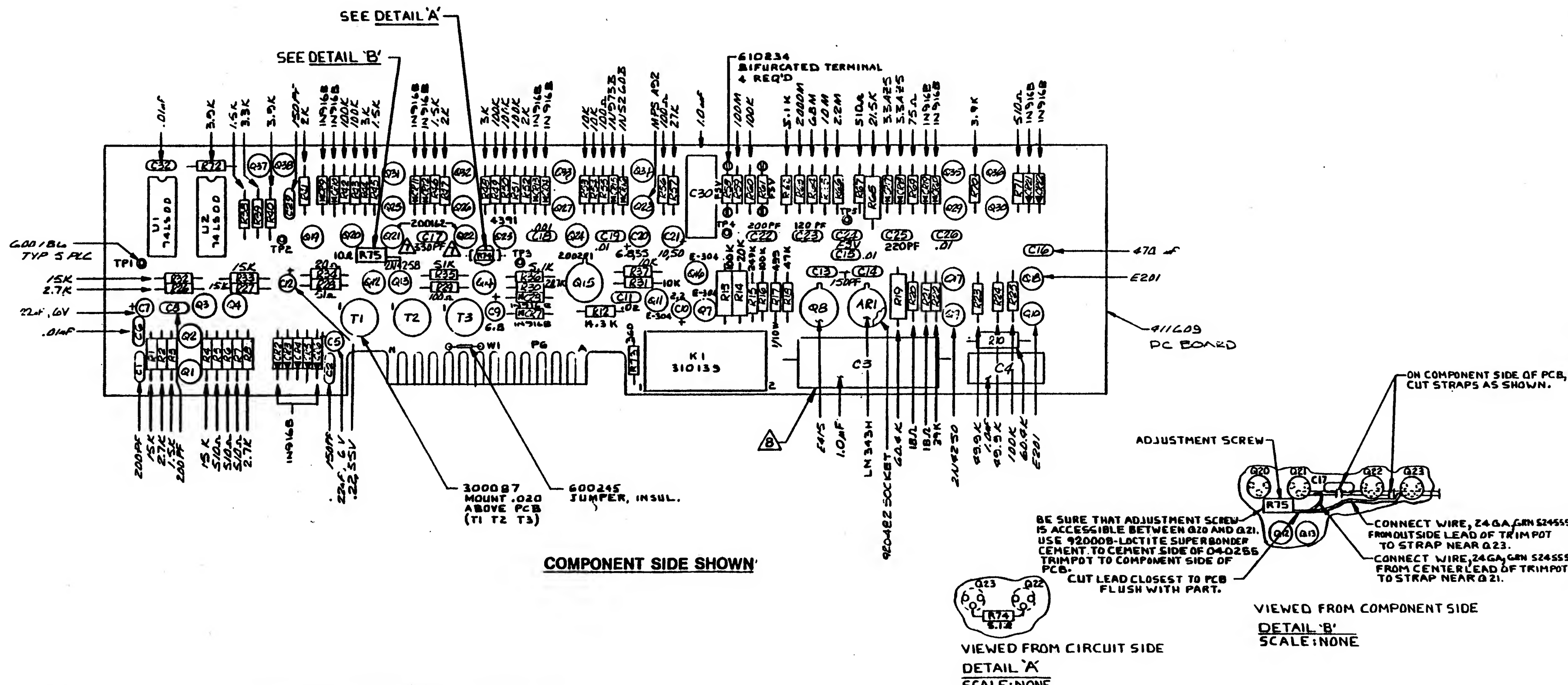
DESIGNATORS

3. RESISTOR NETWORKS ARE ±2%.
2. CAPACITORS ARE IN µF, 100VOLTS, ±20%.
1. RESISTORS ARE IN OHMS, 1/4W, ±5%.
NOTES: UNLESS OTHERWISE SPECIFIED

SCHEMATIC – NON-VOLATILE MEMORY

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	431613	B

SCALE SHEET 1 OF 1



B APPLY APPROX. 1/2" DIA "POOL" OF 920808 ADHESIVE BETWEEN 411609 PC BOARD + 120326 C3.

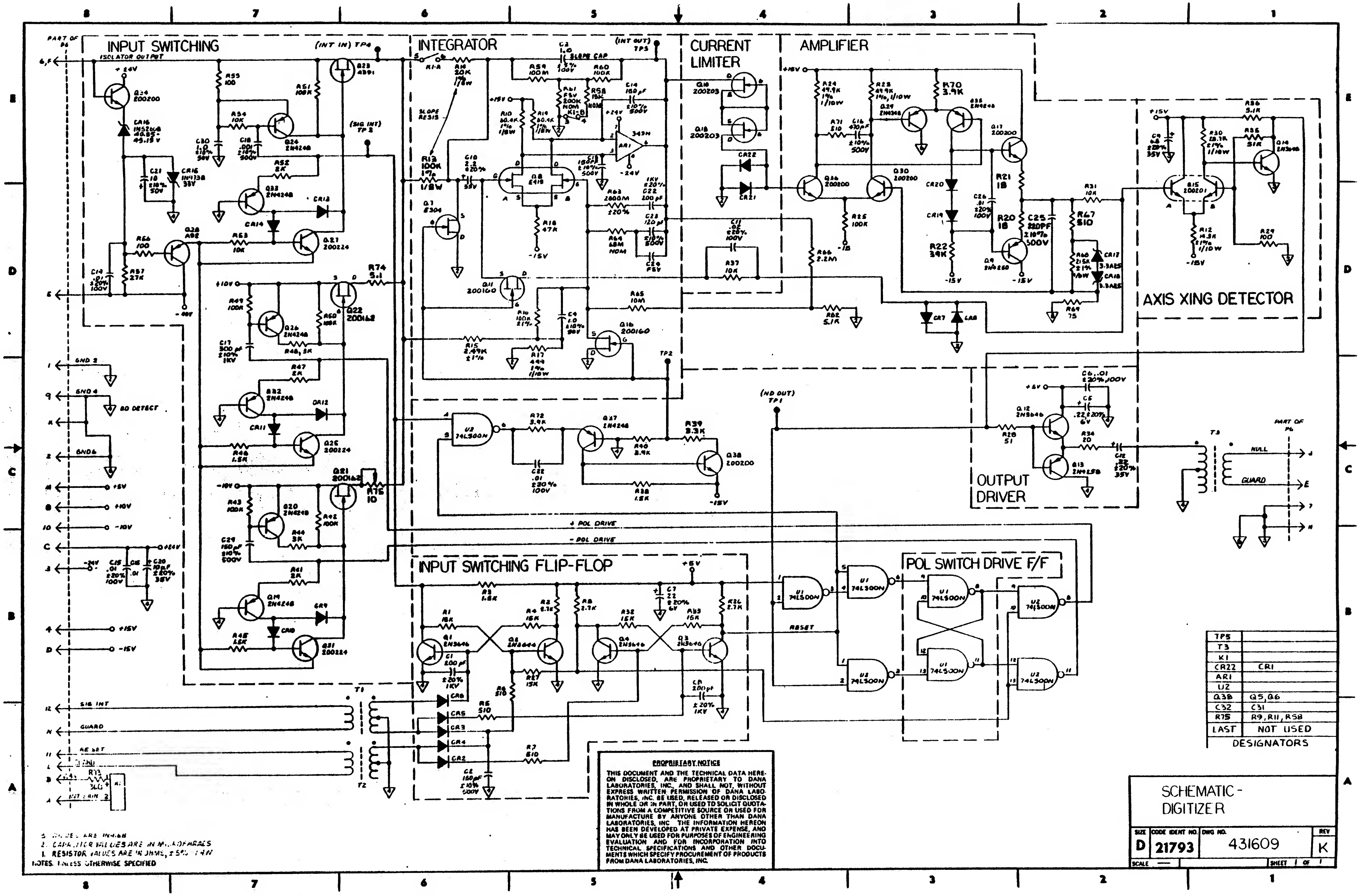
7 INSTALL TWO OF THE THREE 200162 FETS FOR Q21, Q22, DISCARD FET MARKED 200162-6.

6. TRANSISTORS —— Q17, 30, 34, 36, 38 ARE PART NO. 200200.
5. TRANSISTORS Q1, 2, 3, 4, 12, 14 ARE PART NO. 200037.
4. TRANSISTORS Q25, 27, 31 ARE PART NO. 200224.
3. TRANSISTORS Q19, 20, 24, 26, 29, 32, 33, 35, 37 ARE PART NO. 2N4248
2. ASSY PROCESSES & PROCEDURES TO CONFORM TO DANA WORKMANSHIP STANDARDS.
1. SCHEMATIC REF NO 431609

NOTES: UNLESS OTHERWISE SPECIFIED

PCB ASSY
DIGITIZER

SIZE	CODE IDENT NO	DWG NO.	REV
D	21793	401609	N
SCALE 2/1		SHEET 1 OF	



INPUT SWITCHING
INTEGRATOR
CURRENT LIMITER
AMPLIFIER
AXIS XING DETECTOR
OUTPUT DRIVER
INPUT SWITCHING FLIP-FLOP
POL SWITCH DRIVE F/F
PROPRIETARY NOTICE
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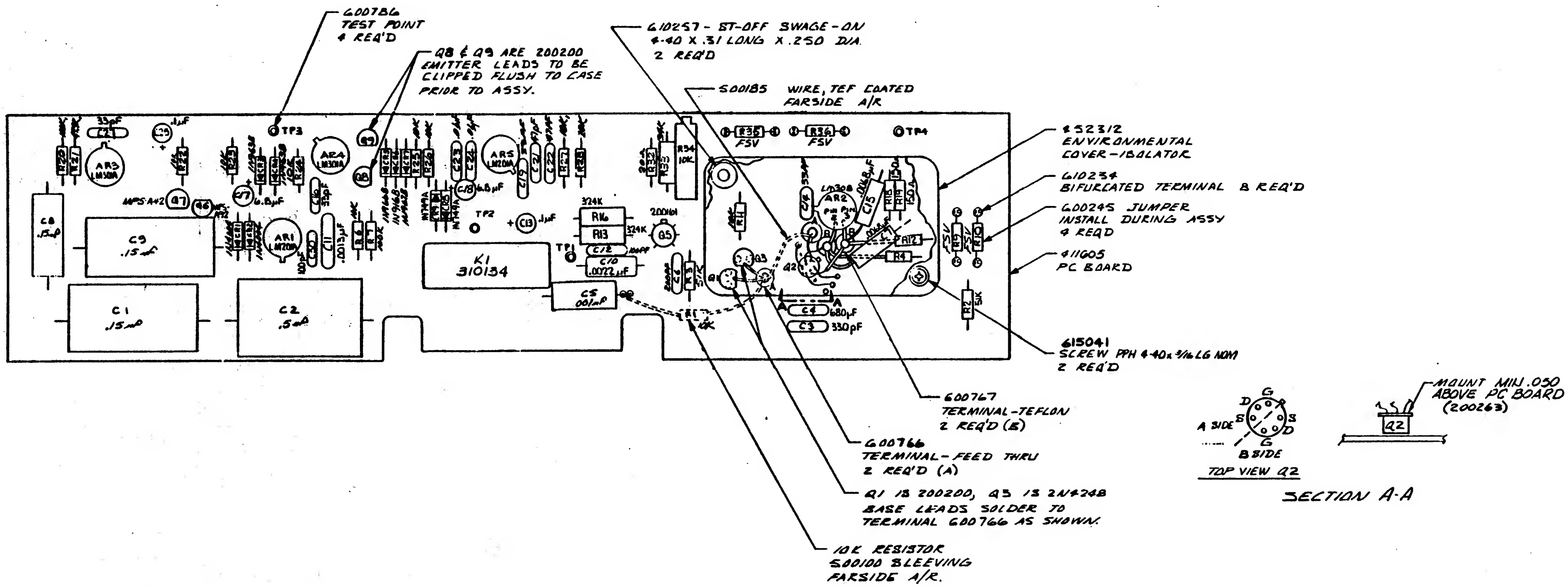
TP5
T3
K1
CR22 CR1
AR1
U2
Q38 Q5,Q6
C32 C31
R75 R9,R11,R58
LAST NOT USED
DESIGNATORS
SCHEMATIC - DIGITIZER
SIZE D
CODE IDENT NO. 21793
DWG NO. 431609
REV K

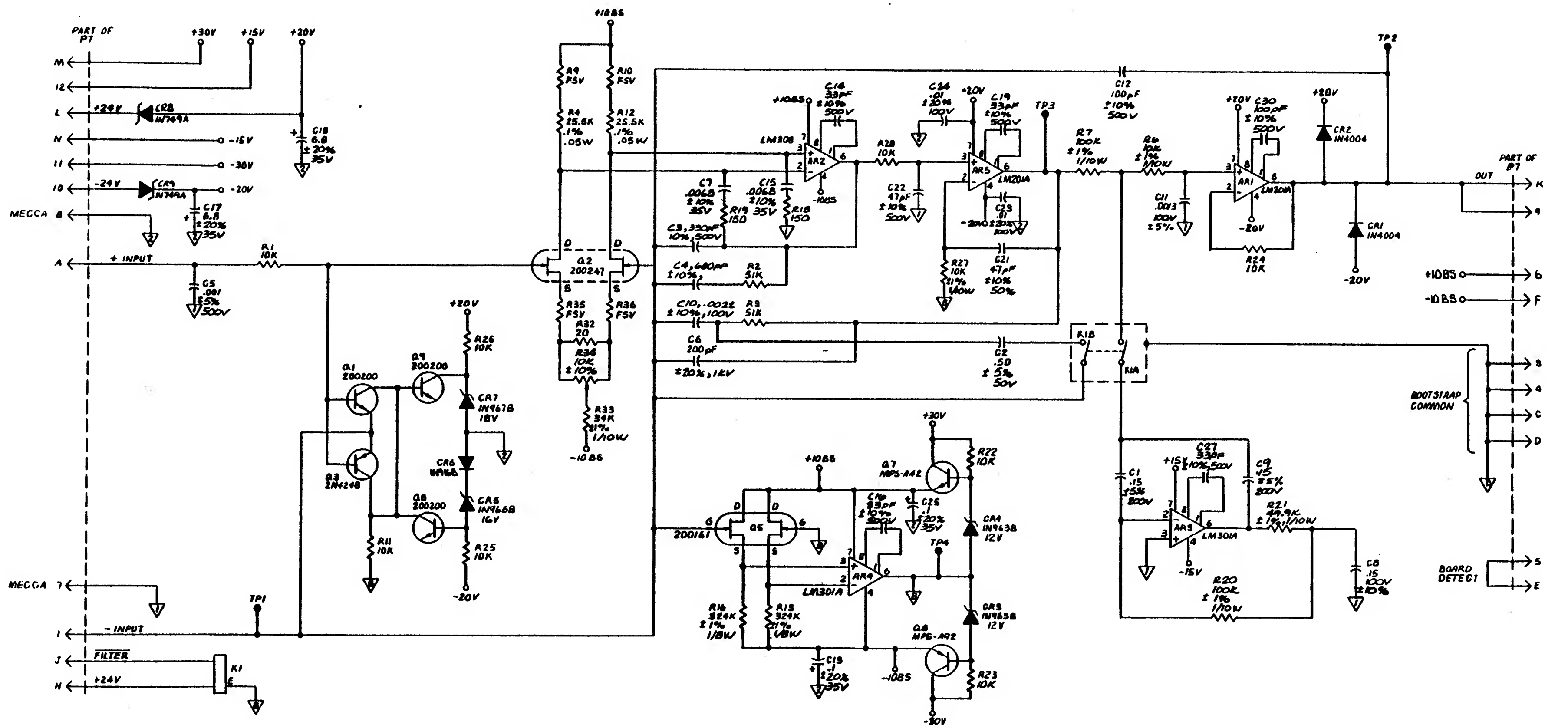


2. REFERENCE SCHEMATIC NO. 431605.
1. ASSEMBLE PER RACAL-DANA WORKMANSHIP MANUAL.
NOTES: UNLESS OTHERWISE SPECIFIED

ASSY
FET ISOLATOR

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	411605	K

SCALE | SHEET 1 OF 2



TP4	
R36	R5,8,14,15,17 R29-31
CR9	
C30	C20,24,28,29
Q9	Q4
K1	
AR5	
LAST USED	NOT USED
DESIGNATORS	

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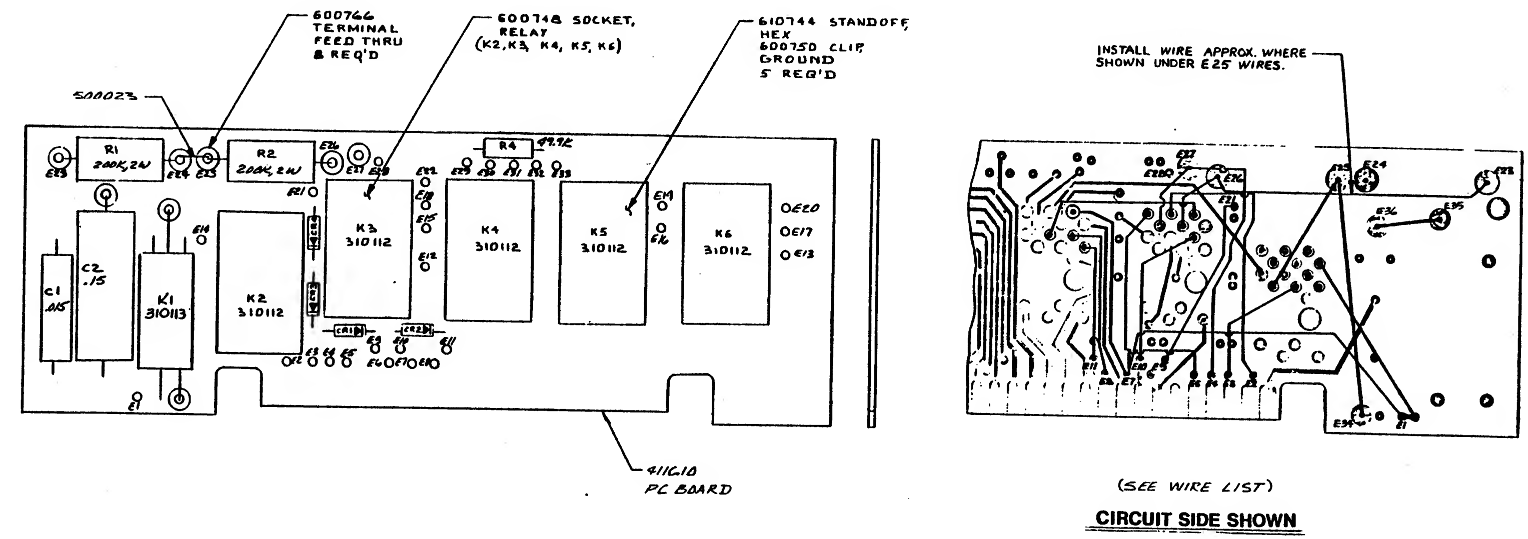
SCHEMATIC - ISOLATOR

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	431605	C
SCALE NONE		SHEET 1 OF 1	

2. CAPACITORS ARE IN MICROFARADS.
1. ALL RESISTORS IN OHMS ± 5%, 1/4 WATT.
NOTES: UNLESS OTHERWISE SPECIFIED



3. ALL DIODES ARE 211083.

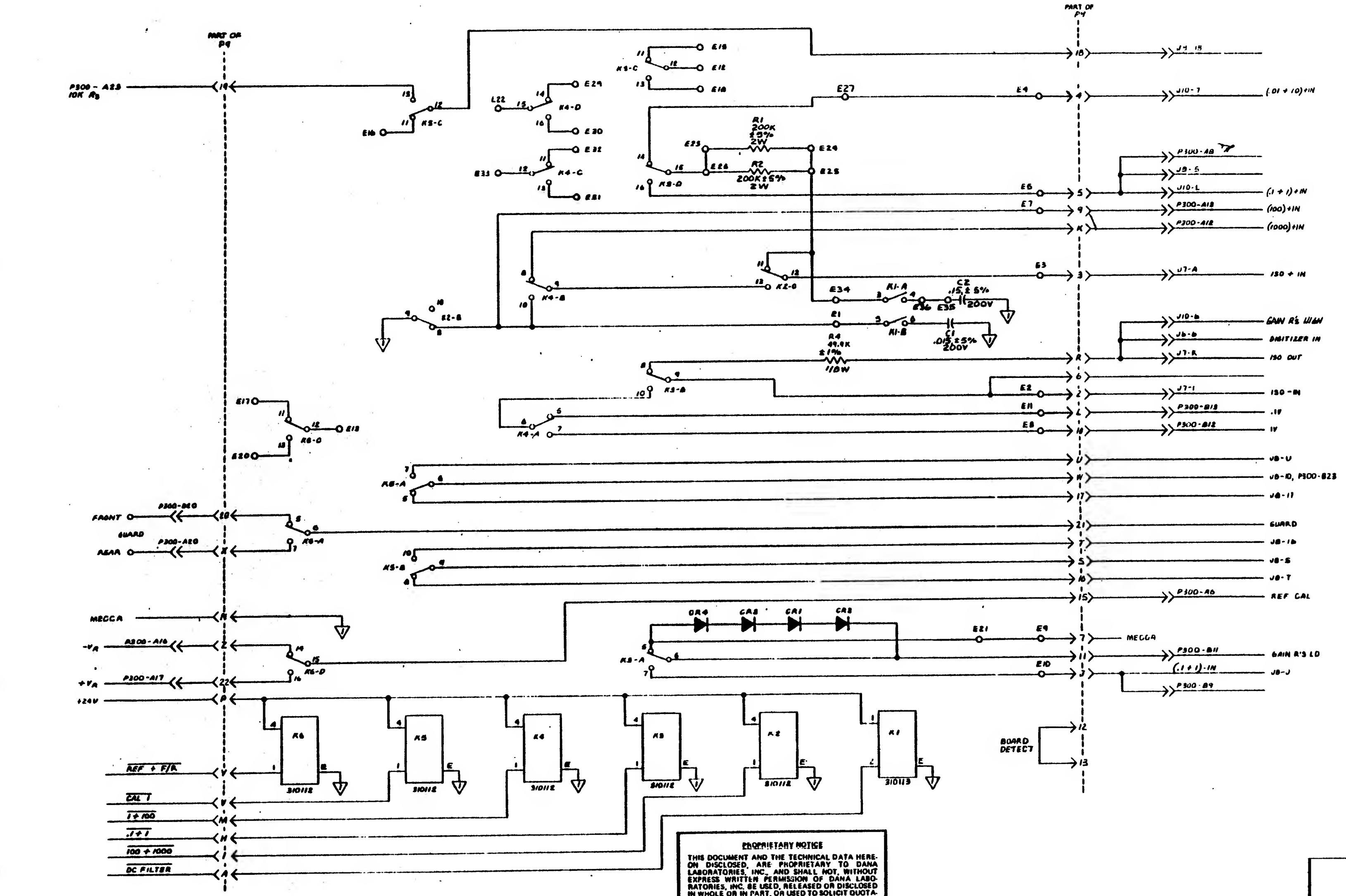
2. ASSY PROCESSES & PROCEDURES TO CONFORM TO DANA WORKMANSHIP STANDARDS.

1. REF SCHEMATIC NO 431610.

NOTES: UNLESS OTHERWISE SPECIFIED

PCB ASSY
SWITCHING

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	401610	E
SCALE 2/1		SHEET 1 OF 4	



K6	
CR4	
C2	
R4	K3
LAST	NOT USED

DESIGNATORS

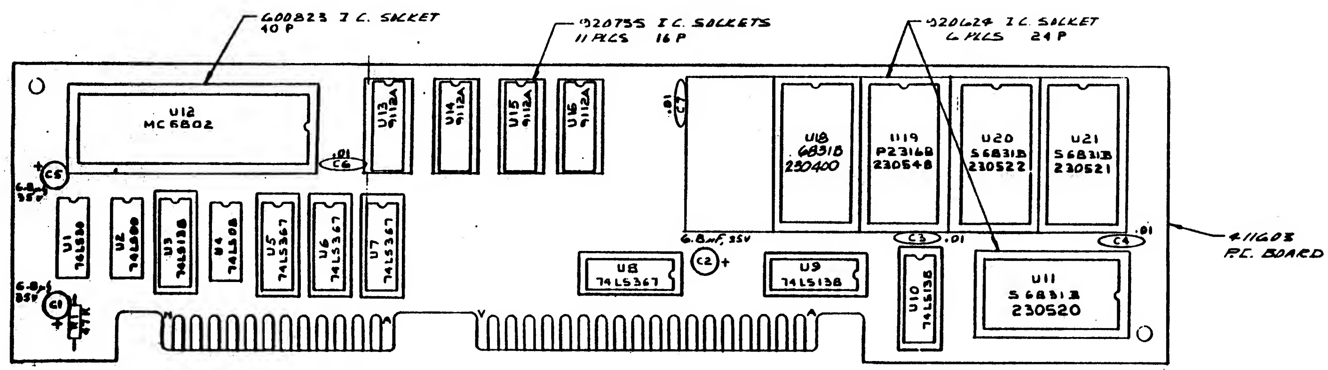
NOTES: UNLESS OTHERWISE SPECIFIED

1. DIODES ARE IN916B

SCHEMATIC-SWITCHING

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	431610	A

SCALE SHEET 1 OF 1

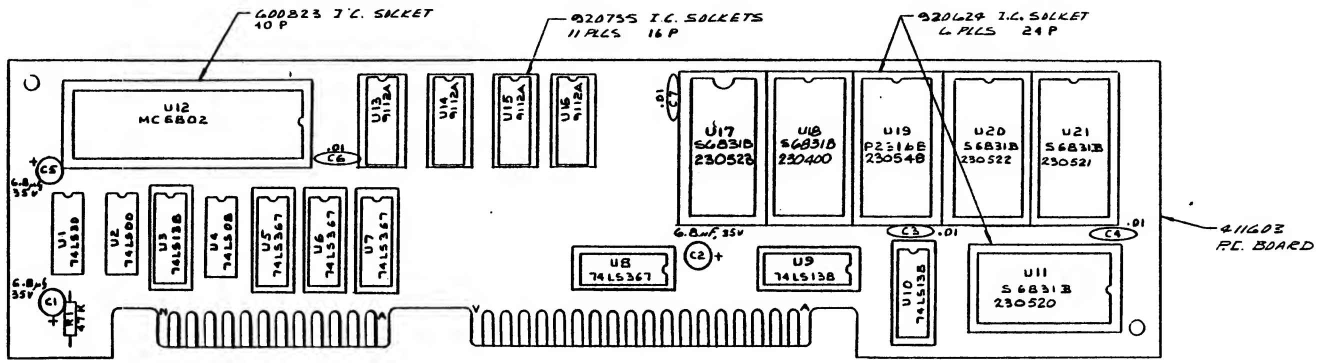


COMPONENT SIDE SHOWN

2. REF SCHEMATIC DWG 431603.
1. ASSY PROCESSES & PROCEDURES TO CONFORM TO DANA WORKMANSHIP STANDARDS.
NOTES: UNLESS OTHERWISE SPECIFIED

PCB ASSY
COMPUTER 1

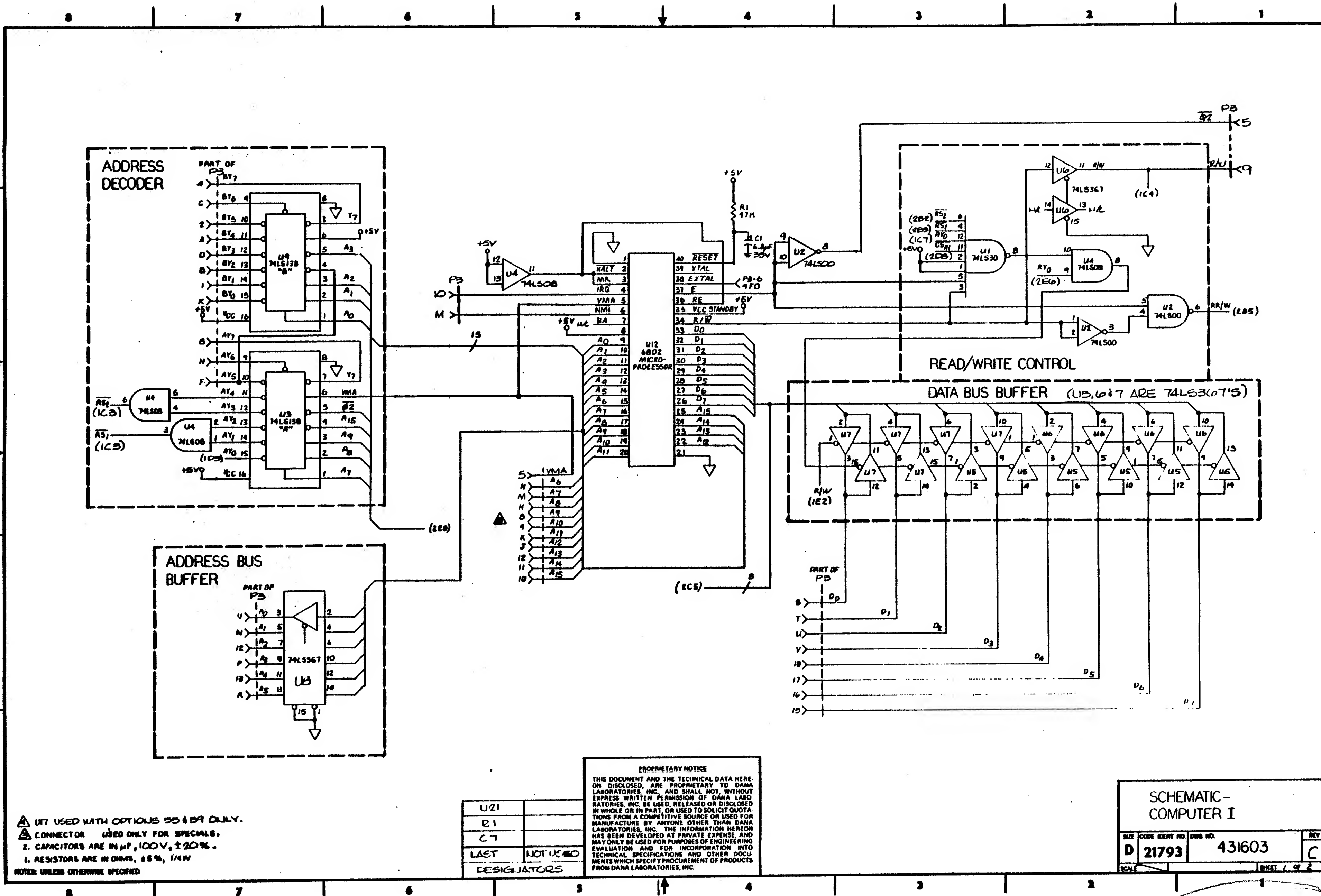
SIZE	CODE IDENT NO	DWG NO.	REV
D	21793	401603	E
SCALE 2/1		SHEET 1 OF 5	



COMPONENT SIDE SHOWN

2 REF. SCHEMATIC DWG 431603.
1. ASSY PROCESSES & PROCEDURES TO CONFORM TO DANA WORKMANSHIP STANDARDS.
NOTES: UNLESS OTHERWISE SPECIFIED

PCB ASSY COMPUTER 1			
SIZE	CODE IDENT NO	DWG NO.	REV
D	21793	404171	B
SCALE 2/1		SHEET 1 OF 3	



NOTES: UNLESS OTHERWISE SPECIFIED
1. RESISTORS ARE IN OHMS, ±5%, 1/4W
2. CAPACITORS ARE IN µF, 100V, ±20%.
3. CONNECTOR USED ONLY FOR SPECIALS.
4. U17 USED WITH OPTIONS 55 & 59 ONLY.

LAST	NOT USED
U21	
R1	
C7	

DESIGNATORS

PROPRIETARY NOTICE

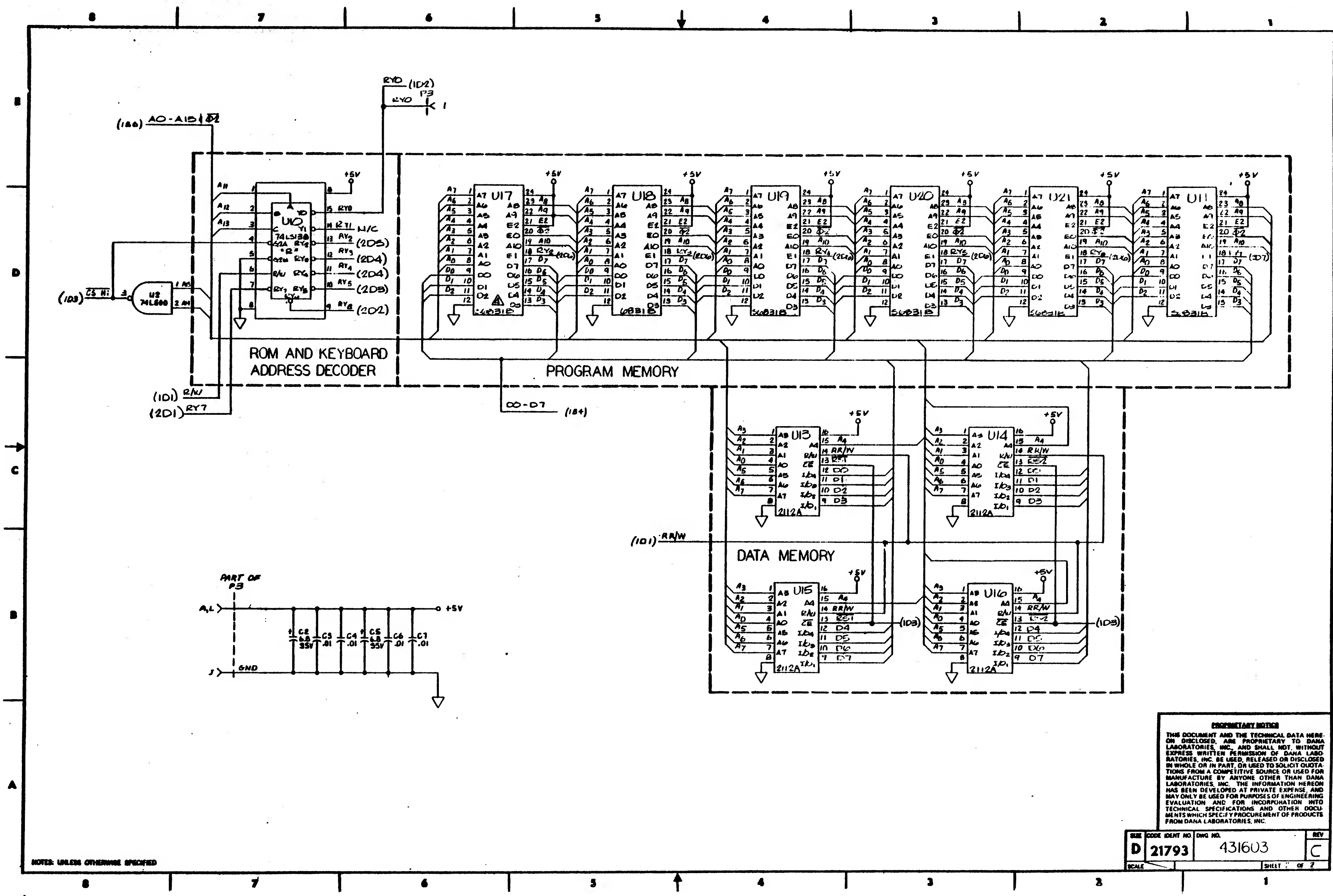
SCHEMATIC - COMPUTER I

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	431603	C

SHEET 1 OF 2

1 of 2

2 of 2



ROM AND KEYBOARD ADDRESS DECODER
PROGRAM MEMORY
DATA MEMORY
U2 74LS00
U10 74LS138
U17
U18
U19
U20
U21
U11
U13
U14
U15
U16
2112A
(1A6) A0-A15 | Φ2
(1D3) CS N1
(1D1) R/W
(2D1) RY7
RY0 (1D2)
P3
D0-D7 (1B4)
(1D1) RR/W
(1D3)
PART OF P3
GND
+5V
NOTES: UNLESS OTHERWISE SPECIFIED
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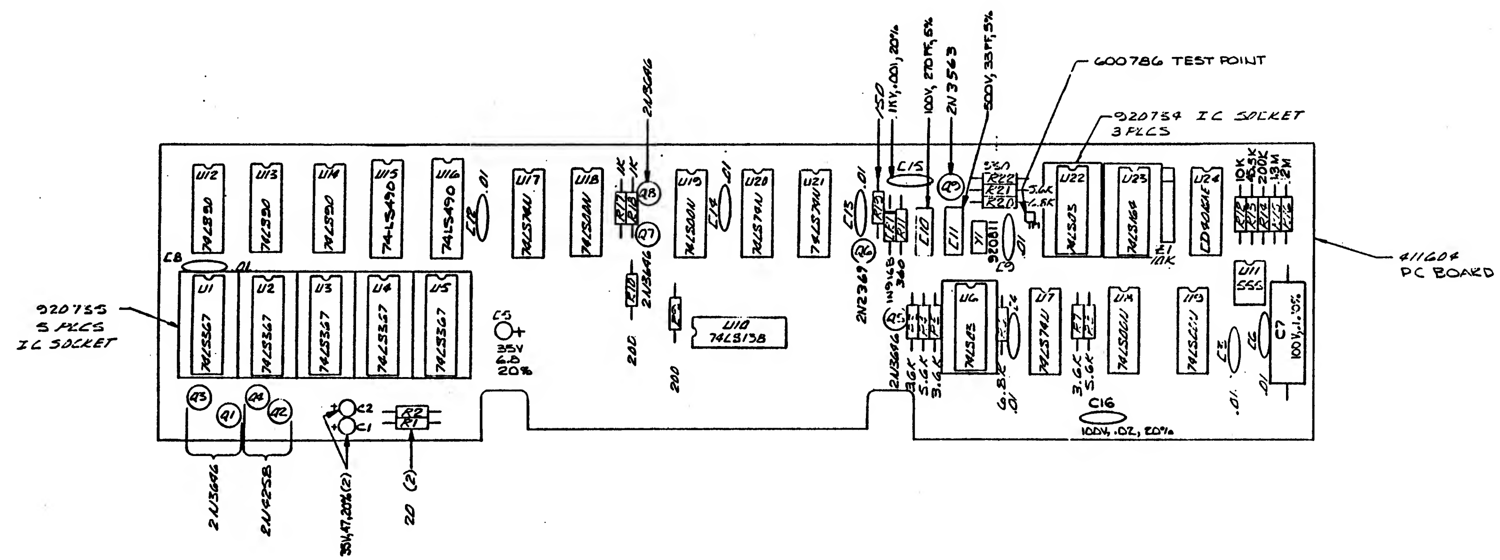
SIZE D
CODE IDENT NO. 21793
DWG NO. 431603
REV C
SHEET 2 OF 2



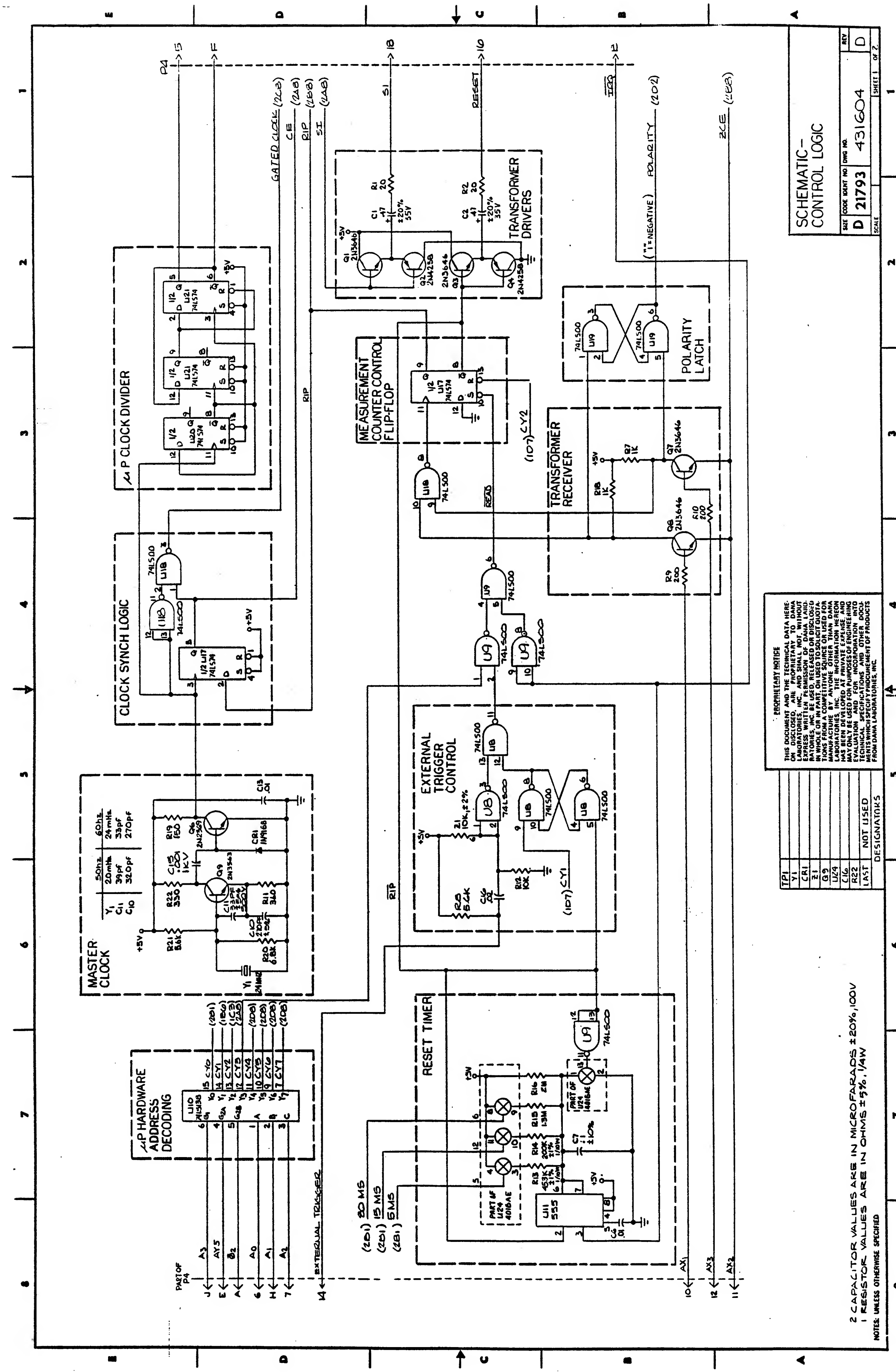
4. CAPACITOR VALUES ARE IN MICROFARADS.
3. RESISTOR VALUES ARE IN OHMS, ±5%, 1/4W.
2. REF SCHEMATIC 431604.
1. ASSY PROCESSES & PROCEDURES TO CONFORM TO DANA WORKMANSHIP STANDARDS.

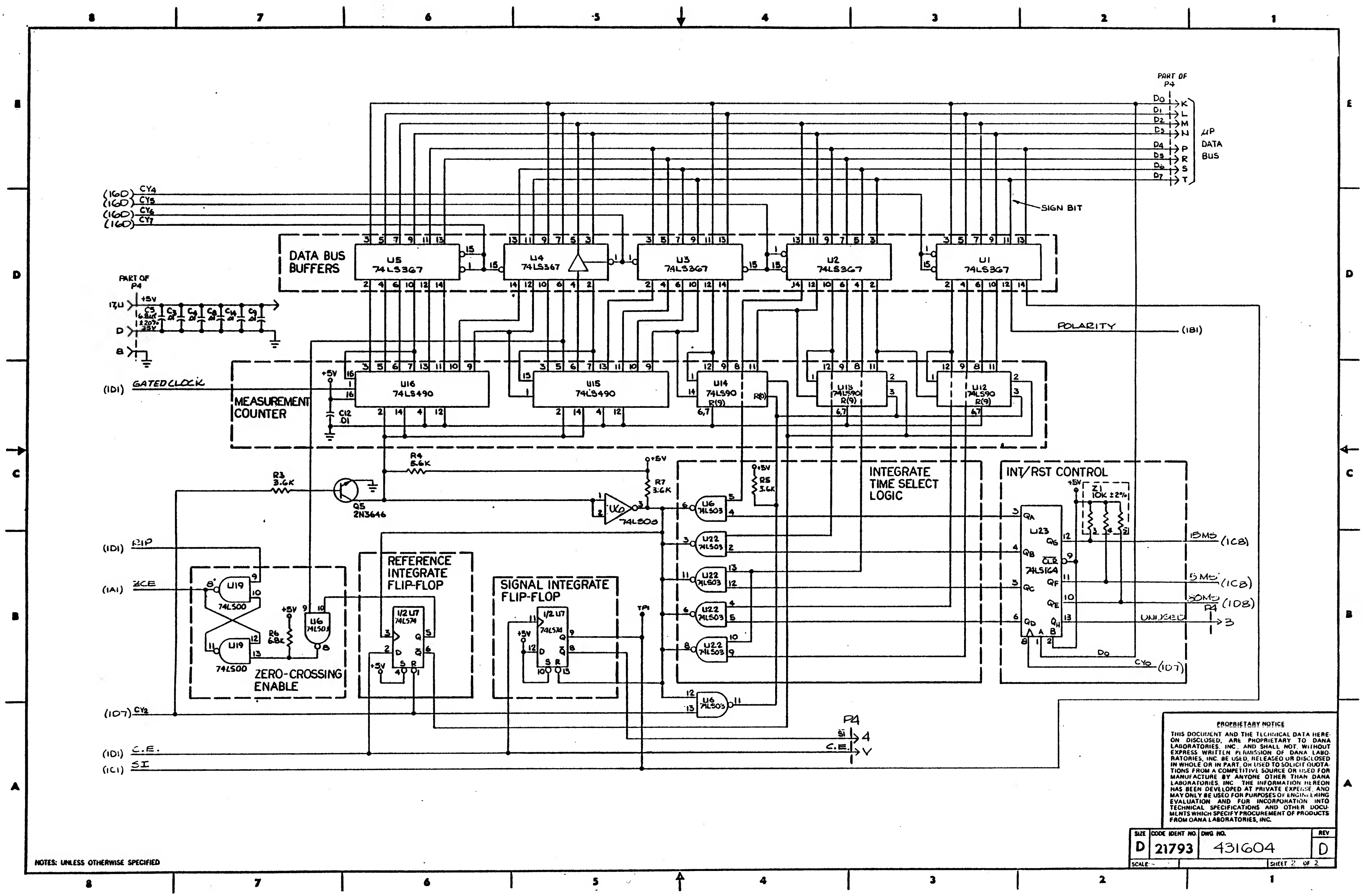
NOTES: UNLESS OTHERWISE SPECIFIED

P.C.B. ASSY
CONTROL LOGIC

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	401604	K

SCALE 2X 1 SHEET 1 OF 2


SCHEMATIC–CONTROL LOGIC
D 21793 431604 D
NOTES: UNLESS OTHERWISE SPECIFIED
1 RESISTOR VALUES ARE IN OHMS ±5%, 1/4W
2 CAPACITOR VALUES ARE IN MICROFARADS ±20%, 100V
MASTER CLOCK
μP CLOCK DIVIDER
CLOCK SYNCH LOGIC
TRANSFORMER DRIVERS
MEASUREMENT COUNTER CONTROL FLIP-FLOP
POLARITY LATCH
TRANSFORMER RECEIVER
EXTERNAL TRIGGER CONTROL
μP HARDWARE ADDRESS DECODING
RESET TIMER
PROPRIETARY NOTICE


DATA BUS BUFFERS
U5 74LS367
U4 74LS367
U3 74LS367
U2 74LS367
U1 74LS367
MEASUREMENT COUNTER
U16 74LS490
U15 74LS490
U14 74LS90
U13 74LS90
U12 74LS90
PART OF P4
D_0 K
D_1 L
D_2 M
D_3 N
D_4 P
D_5 R
D_6 S
D_7 T
μP DATA BUS
SIGN BIT
POLARITY (1B1)
(16D) CY4
(16D) CY5
(16D) CY6
(16D) CY7
PART OF P4
+5V
C5 6.8μF ±20% 35V
(1D1) GATED CLOCK
C12 .01
R4 5.6K
R3 3.6K
Q5 2N3646
R7 3.6K
U6 74LS05
R5 3.6K
INTEGRATE TIME SELECT LOGIC
U16 74LS03
U22 74LS03
INT/RST CONTROL
Z1 10K ±2%
U23 74LS164
15MS (1C8)
5MS (1C8)
30MS (1D8)
UNUSED
P4 3
D_0
CY_0 (1D7)
(1D1) RIP
(1A1) ZCE
U19 74LS00
R6 68K
U16 74LS03
ZERO-CROSSING ENABLE
REFERENCE INTEGRATE FLIP-FLOP
1/2 U17 74LS74
SIGNAL INTEGRATE FLIP-FLOP
1/2 U17 74LS74
TP1
(1D7) CY2
P4
SI 4
C.E. V
(1D1) C.E.
(1C1) SI
NOTES: UNLESS OTHERWISE SPECIFIED
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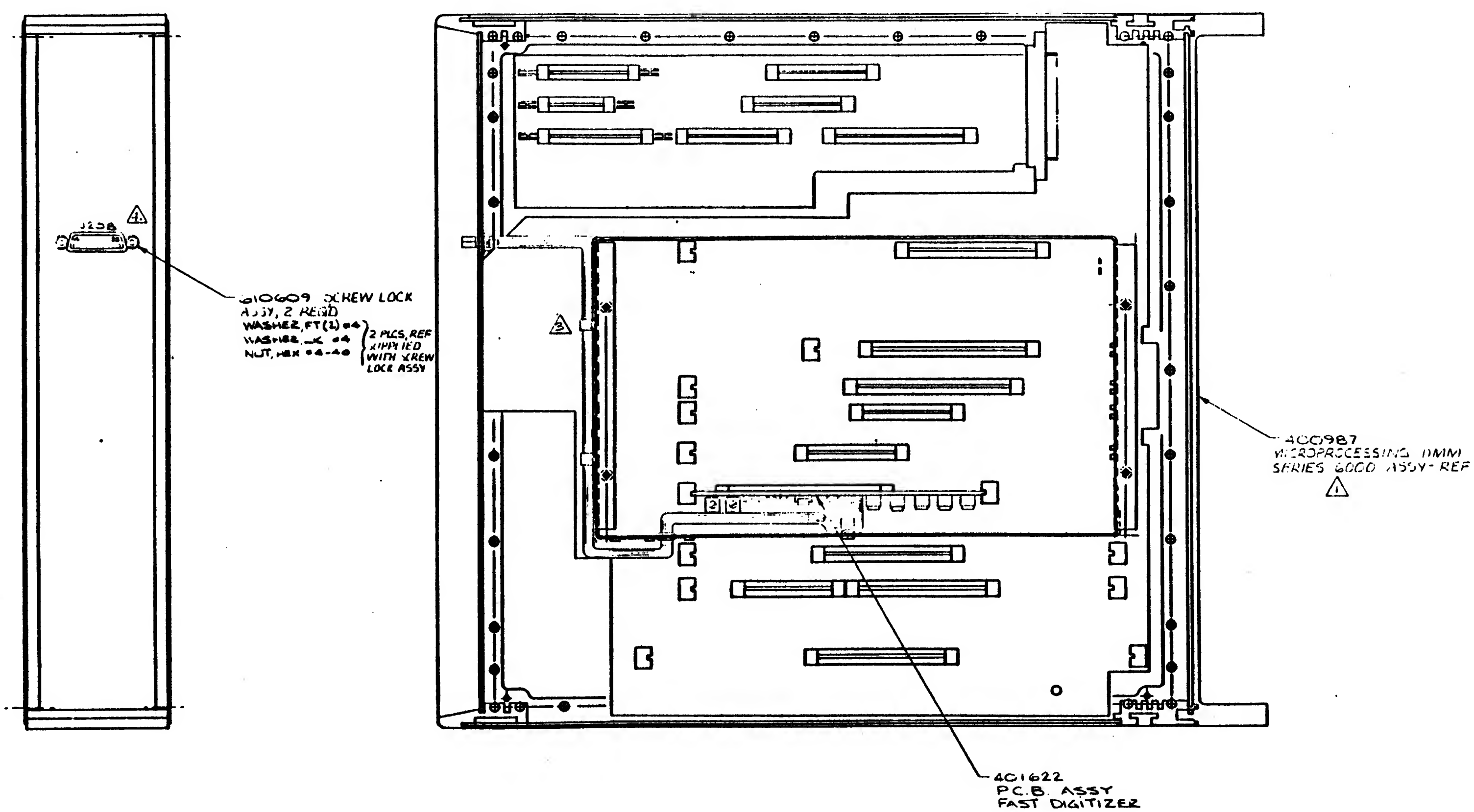
SIZE D
CODE IDENT NO. 21793
DWG NO. 431604
REV D
SHEET 2 OF 2

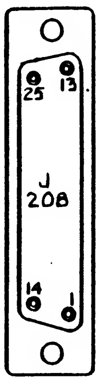


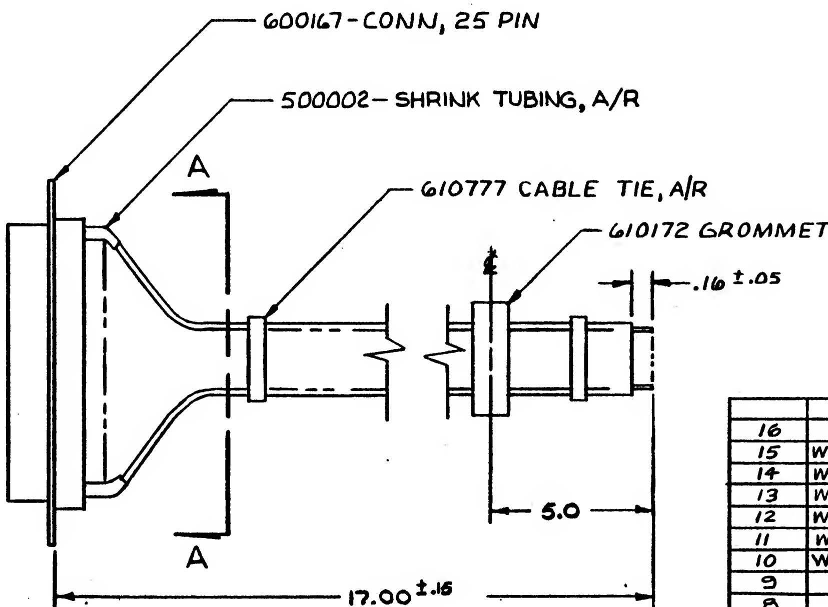
4. REMOVE BUTCH PLATE 404184 BEFORE MTG CONNECTOR
3. ROUTE CABLE THRU EXISTING CLAMPS (610491) ON 454177 SHIELD
2. ASSEMBLE PER DANA WORKMANSHIP MANUAL
1. COVERS AND OTHER PCB ASSY'S NOT SHOWN FOR CLARITY

NOTES: UNLESS OTHERWISE SPECIFIED

FAST DIGITIZER
OPTION ASSY

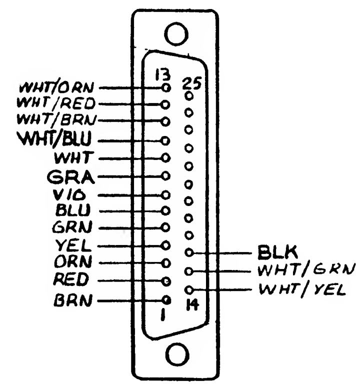
SIZE	CODE IDENT NO	DWG NO.	REV
D	21793	4C4021	B
SCALE:		SHEET OF 2	





J208 PIN #	COLOR	PART NO.
16	BLK	524000
15	WHT/GRN	524959
14	WHT/YEL	524949
13	WHT/ORN	524939
12	WHT/RED	524929
11	WHT/BRN	524919
10	WHT/BLU	524969
9	WHT	524999
8	GRA	524888
7	VIO	524777
6	BLU	524666
5	GRN	524555
4	YEL	524444
3	ORN	524333
2	RED	524222
1	BRN	524111

WIRE LIST



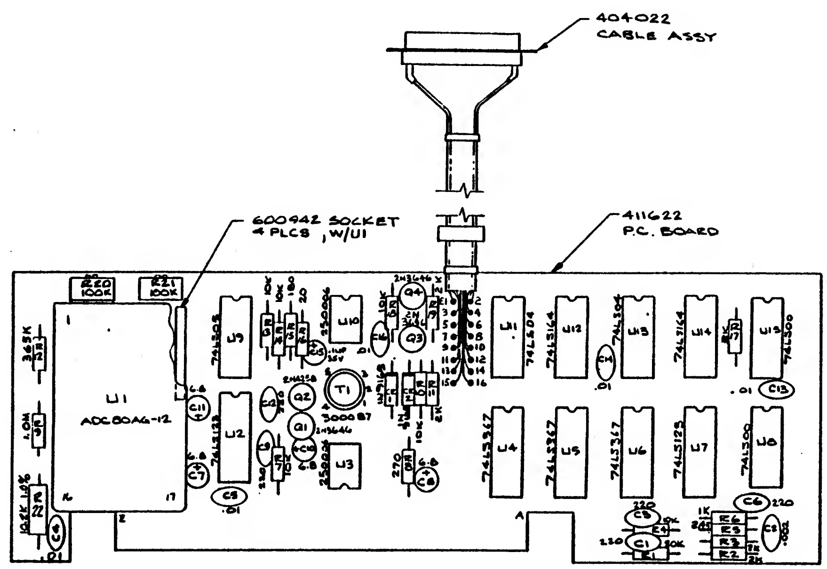
VIEW A-A
SCALE 2/1

NOTES: UNLESS OTHERWISE SPECIFIED
1. ASSY PROCESSES & PROCEDURES TO CONFORM TO DANA WORK. STDS.
2. TAG & IDENTIFY WITH DANA P/N & CURRENT REV LTR.

CABLE ASSEMBLY- FAST DIGITIZER

SIZE	CODE IDENT NO	DWG NO	REV
C	21793	404022	A

SCALE 2:1 SHEET 1 OF 2



COMPONENT SIDE SHOWN

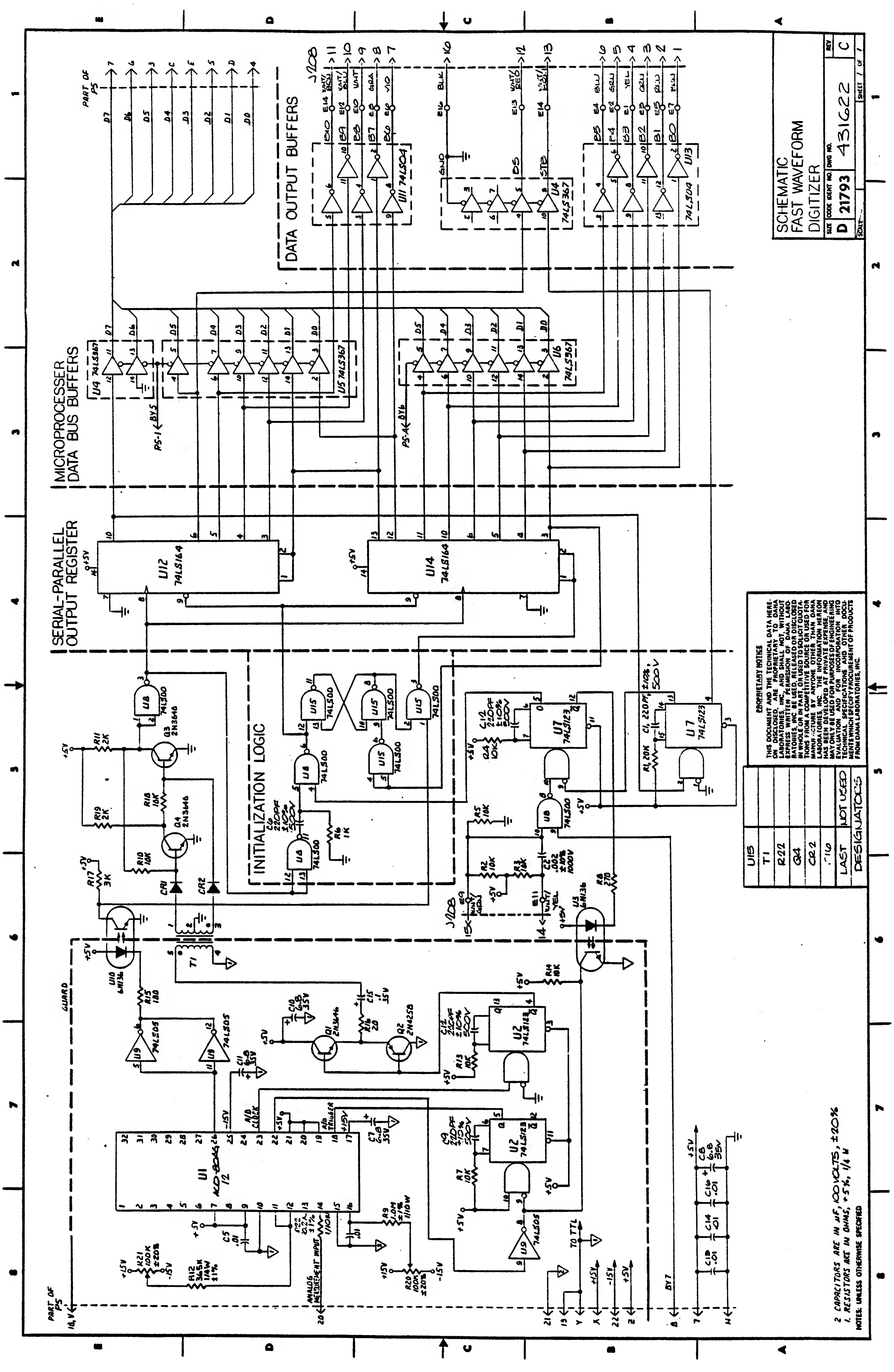
CABLE COLORS		
REF DES	COLOR	J208 PIN NO
E1	YEL	4
E2	GRN	5
E3	ORN	3
E4	BLU	6
E5	RED	2
E6	VIO	7
E7	BRN	1
E8	GRA	8
E9	WHT/GRN	15
E10	WHT	9
E11	WHT/YEL	14
E12	WHT/BLU	10
E13	WHT/RED	12
E14	WHT/BRN	11
E15	WHT/ORN	13
E16	BLK	16

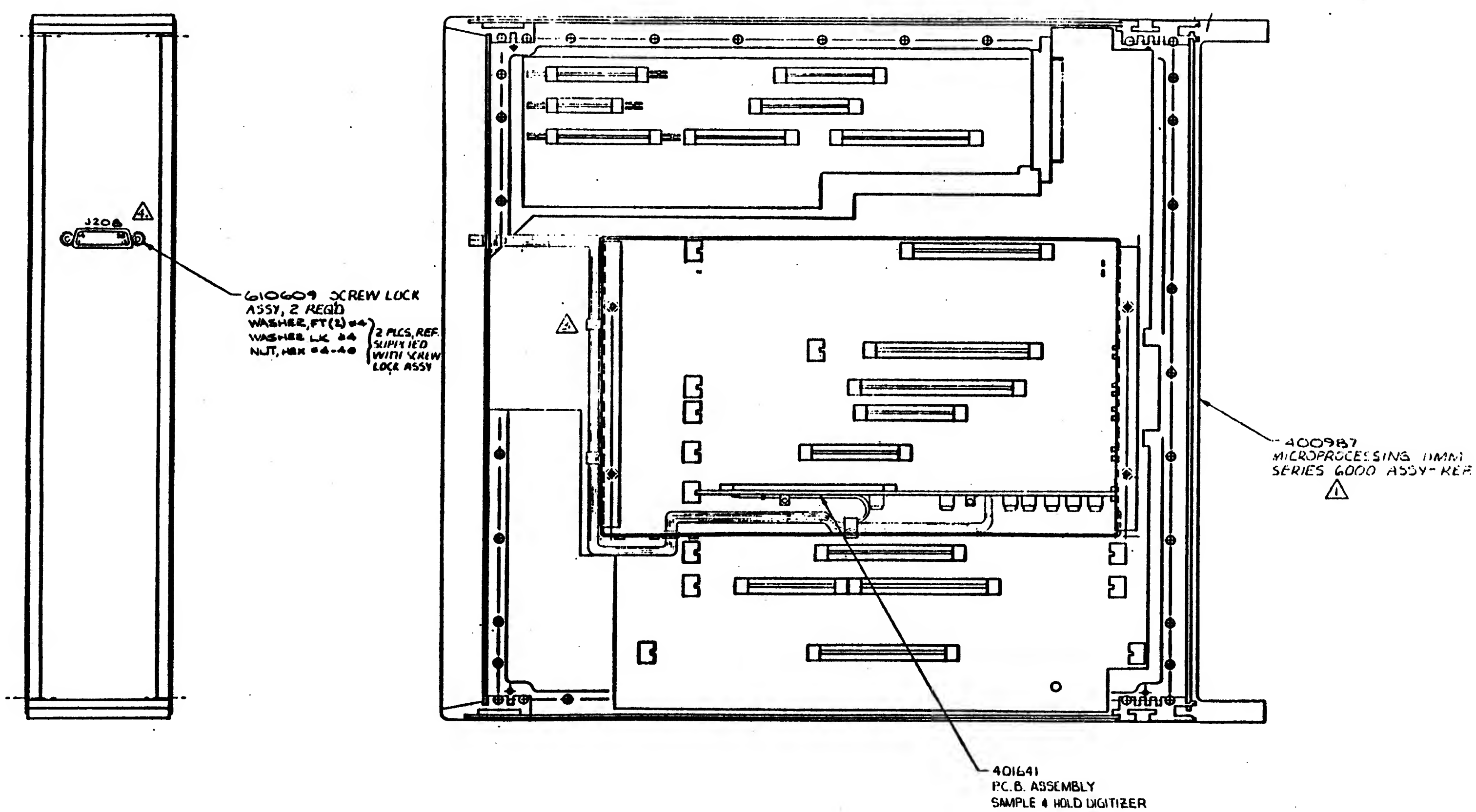
4. CAPACITORS ARE IN µF
3. RESISTORS ARE IN OHMS, ±5%, 1/4W, CC.
2. REF SCHEMATIC NO. 431622
1. ASSY PROCESSES AND PROCEDURES TO CONFORM TO DANA WORKMANSHIP STANDARDS MANUAL.

NOTES: UNLESS OTHERWISE SPECIFIED

P.C. BOARD ASSEMBLY
FAST WAVEFORM
DIGITIZER

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	401622	J
SCALE: 2/1		SHEET 1 OF 3	


SCHEMATIC
FAST WAVEFORM
DIGITIZER
D 21793 431622 C
DATA OUTPUT BUFFERS
MICROPROCESSER
DATA BUS BUFFERS
SERIAL-PARALLEL
OUTPUT REGISTER
INITIALIZATION LOGIC
LAST USED: U15, T1, R22, Q4, CR2, C16
NOT USED
DESIGNATORS
PROPRIETARY NOTICE
2. CAPACITORS ARE IN µF, 100VOLTS, ±20%
1. RESISTORS ARE IN OHMS, ±5%, 1/4 W
NOTES: UNLESS OTHERWISE SPECIFIED

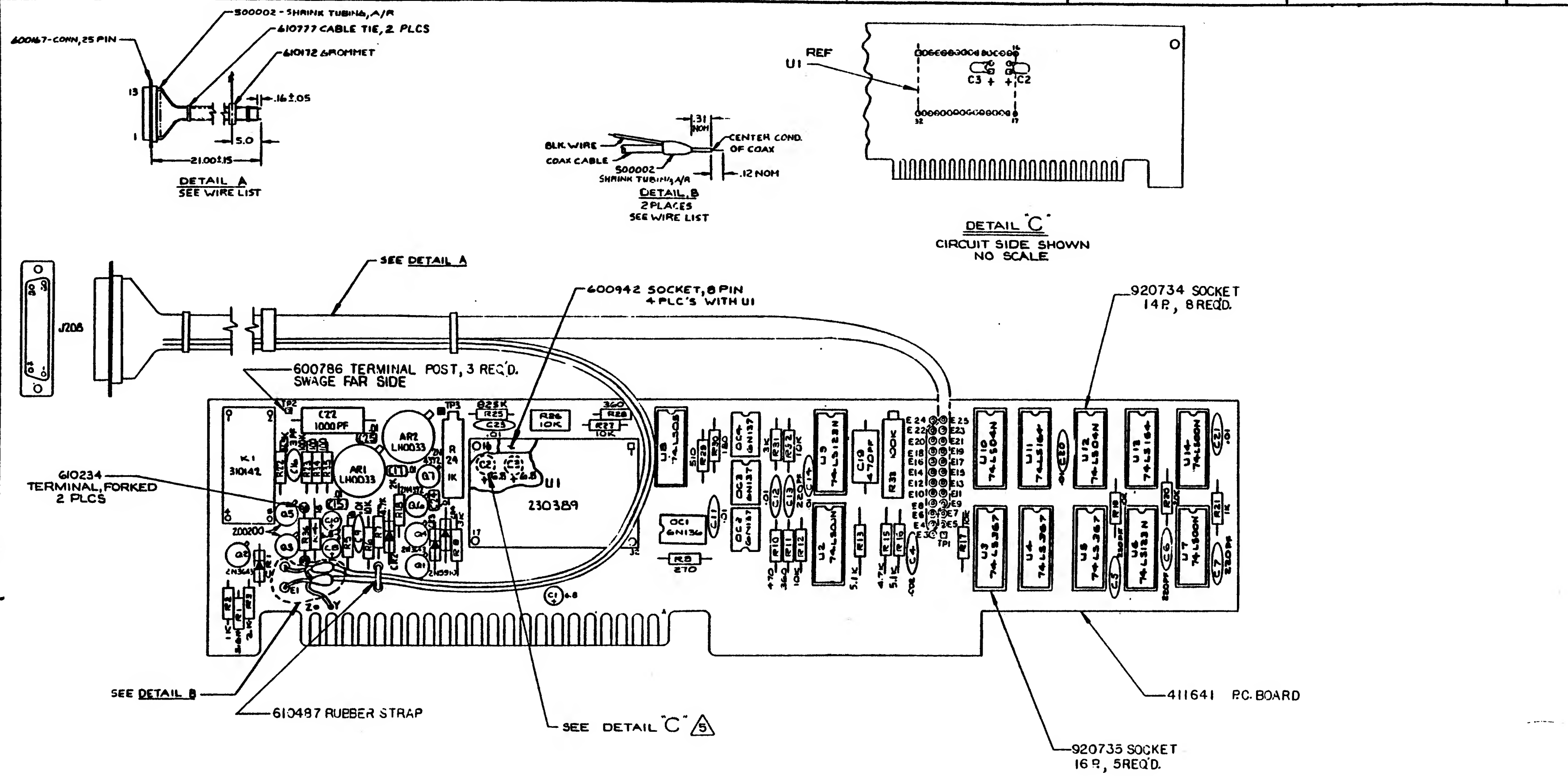


6 TYPE OPTION NO. 03 ON SERIAL NO. TAG USED ON BASIC ASSEMBLY UNIT.
5 PACKAGE & ATTACH MATING CONNECTOR 600166, HOOD 600921 & (2) SCREW LOCK ASSEMBLIES 610246.
4 REMOVE BUTCH PLATE 454184 BEFORE MTG. CONNECTOR J208.
3 ROUTE CABLE THRU EXISTING CLAMPS (610491) ON 454177 SHIELD
2. ASSEMBLE PER RACAL-DANA WORKMANSHIP MANUAL.
1 COVERS AND OTHER P.C.B ASSY'S NOT SHOWN FOR CLARITY
NOTES: UNLESS OTHERWISE SPECIFIED

PROPRIETARY NOTICE

SAMPLE AND HOLD DIGITIZER
ASSEMBLY - OPTION 03

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	404059	A



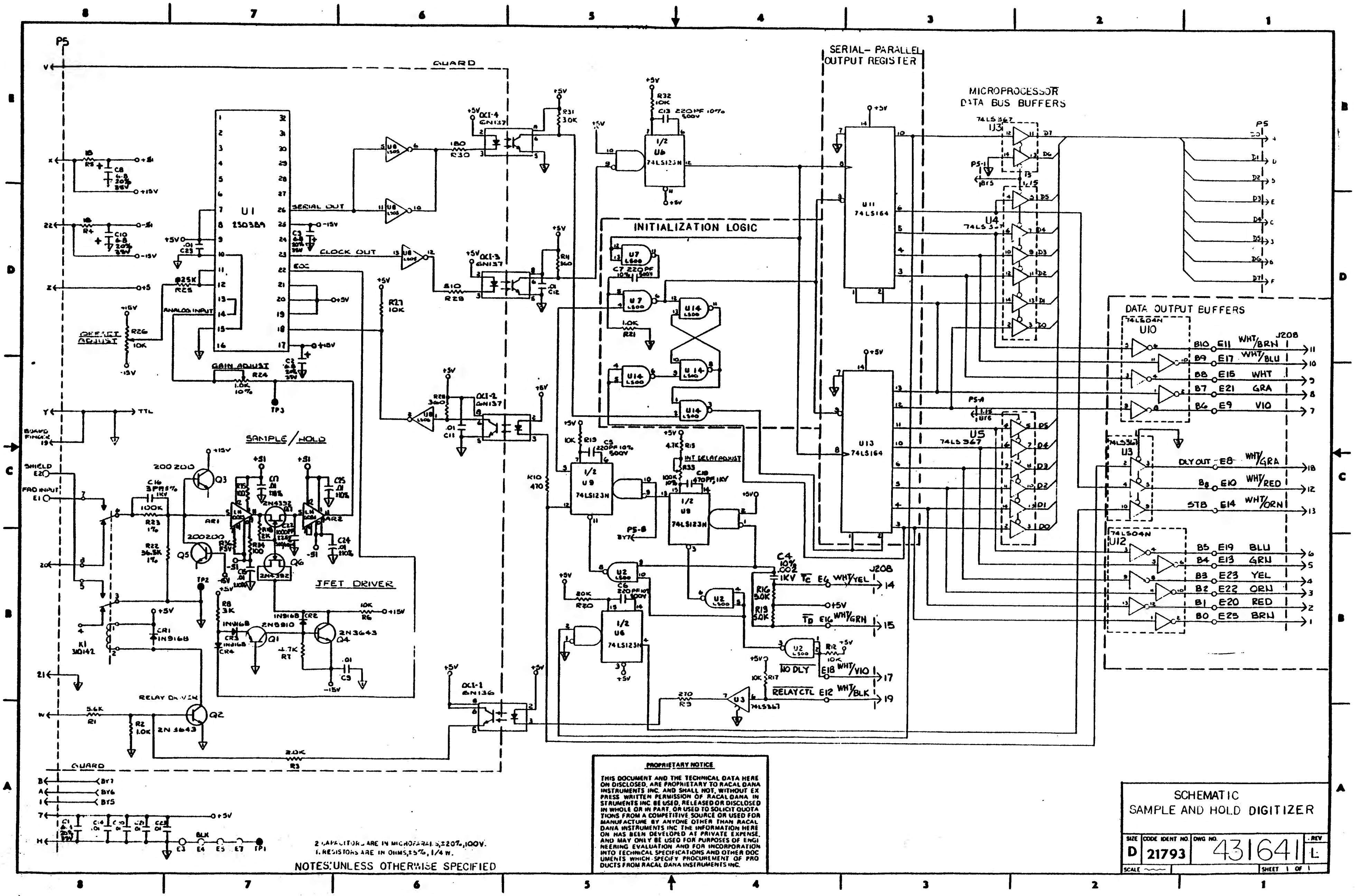
5. INSTALL C2 AND C3 ON CIRCUIT SIDE. BEND CAPS OVER. SEE DETAIL C.
4. ALL DIODES ARE IN916B.
3. ALL CAPACITORS ARE IN MFD.
2. REFERENCE SCHEMATIC NO. 432641.
1. ASSEMBLY PROCESSES & PROCEDURES TO CONFORM TO DANA WORKMANSHIP STANDARDS.

NOTES: UNLESS OTHERWISE SPECIFIED

P.C. BOARD ASSEMBLY
SAMPLE AND HOLD DIGITIZER

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	401641	S

SCALE　　SHEET 1 OF 7


SERIAL-PARALLEL OUTPUT REGISTER
MICROPROCESSOR DATA BUS BUFFERS
INITIALIZATION LOGIC
DATA OUTPUT BUFFERS
SAMPLE/HOLD
JFET DRIVER
GUARD
GAIN ADJUST
OFFSET ADJUST
RELAY DRIVER
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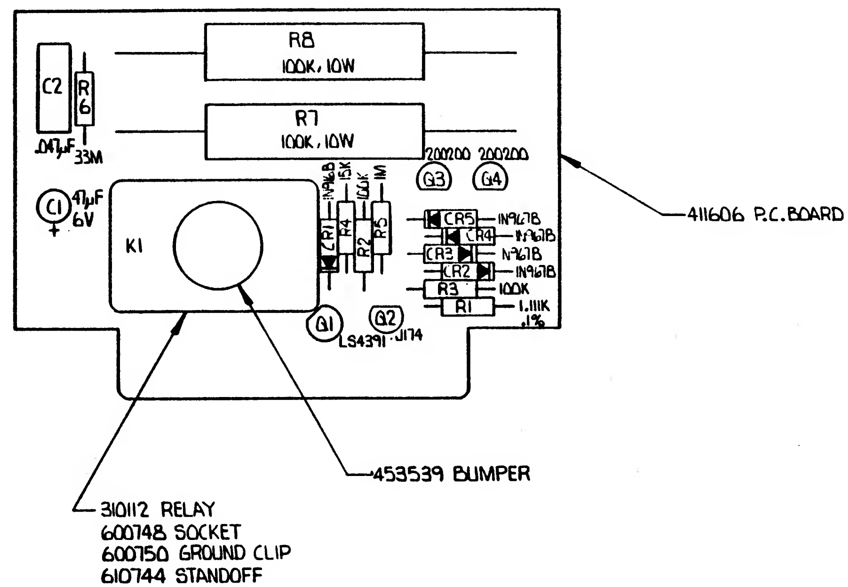
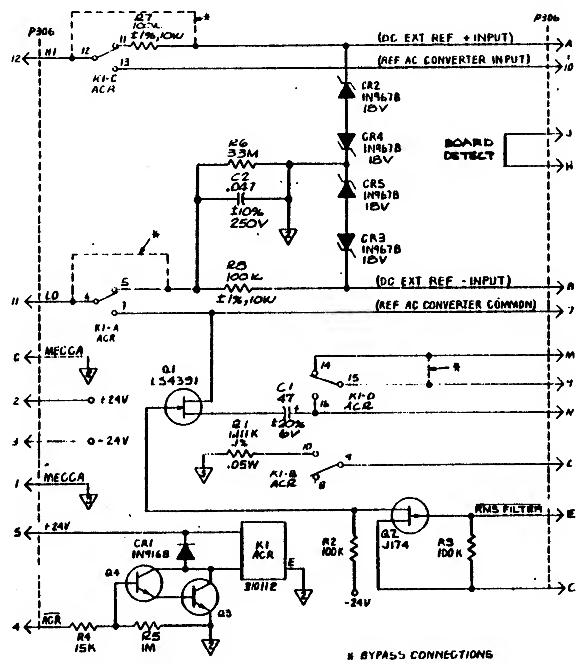
NOTES: UNLESS OTHERWISE SPECIFIED
1. RESISTORS ARE IN OHMS, ±5%, 1/4 W.
2. CAPACITORS ARE IN MICROFARADS, ±20%, 100V.
SCHEMATIC
SAMPLE AND HOLD DIGITIZER
SIZE D
CODE IDENT NO 21793
DWG NO 431641
REV L
SHEET 1 OF 1



2. SCHEMATIC REFERENCE 431606.
1. ASSEMBLY PROCEDURES AND PROCESSES TO CONFORM TO DANA WORKMANSHIP MANUAL.
NOTES: UNLESS OTHERWISE SPECIFIED

~~NOTES: UNLESS OTHERWISE SPECIFIED~~

P.C. BOARD ASSEMBLY RATIO SWITCHING			
SIZE C	CODE IDENT NO 21793	DWG NO 401606	REV B
SCALE 2/1		SHEET OF 2	



NOTES: UNLESS OTHERWISE SPECIFIED
1. TRANSISTORS ARE 200200
2. RESISTORS ARE IN OHMS, ±5%, 1/4W
3. CAPACITORS ARE IN MICROFARADS

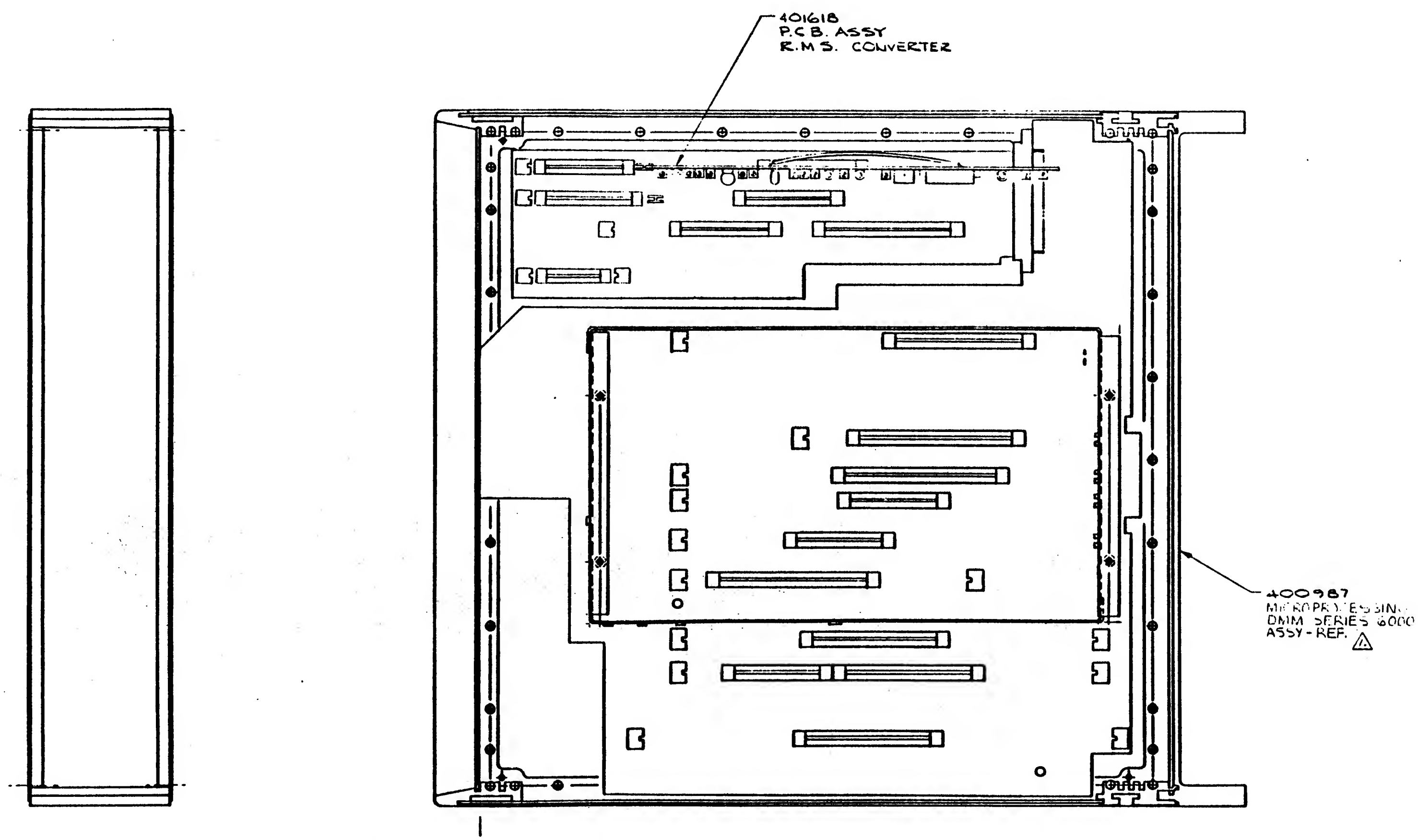
LAST USED	NOT USED
CR5	
Q4	
K1	
C2	
R8	

DESIGNATORS

SCHEMATIC-
RATIO SWITCHING

SIZE	CODE IDENT NO	DWG NO.	REV
D	21793	431606	A

SCALE | SHEET 1 OF 1



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2 ASSEMBLE PER DANA WORKMANSHIP MANUAL

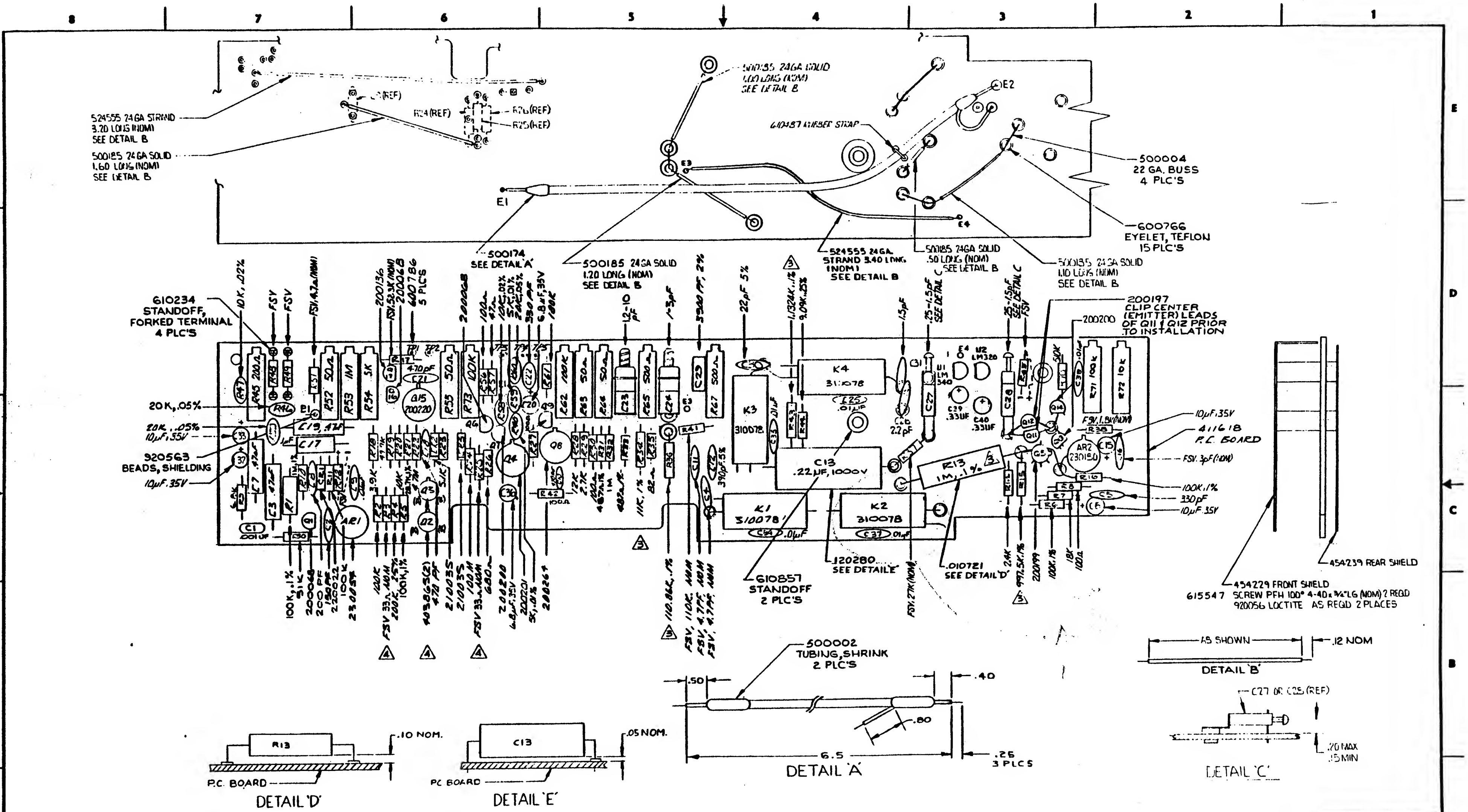
⚠1 COVERS AND OTHER P.C.B ASSY'S NOT SHOWN FOR CLARITY.

NOTES: UNLESS OTHERWISE SPECIFIED

RMS CONVERTER
OPTION ASSY

SIZE	CODE IDENT NO	DWG NO.	REV
D	21793	404027	A

SCALE — SHEET OF 2



4. Q2, Q3, R3 AND R25 ARE LOGIC TRANSISTOR KIT 403865.
3. R13, R15, R34, R36 AND R43 ARE RESISTOR SET 010721.
2. REF SCHEMATIC 431618
1. ASSY PROCESSES & PROCEDURES TO CONFORM TO DANA WORKMANSHIP STANDARDS.

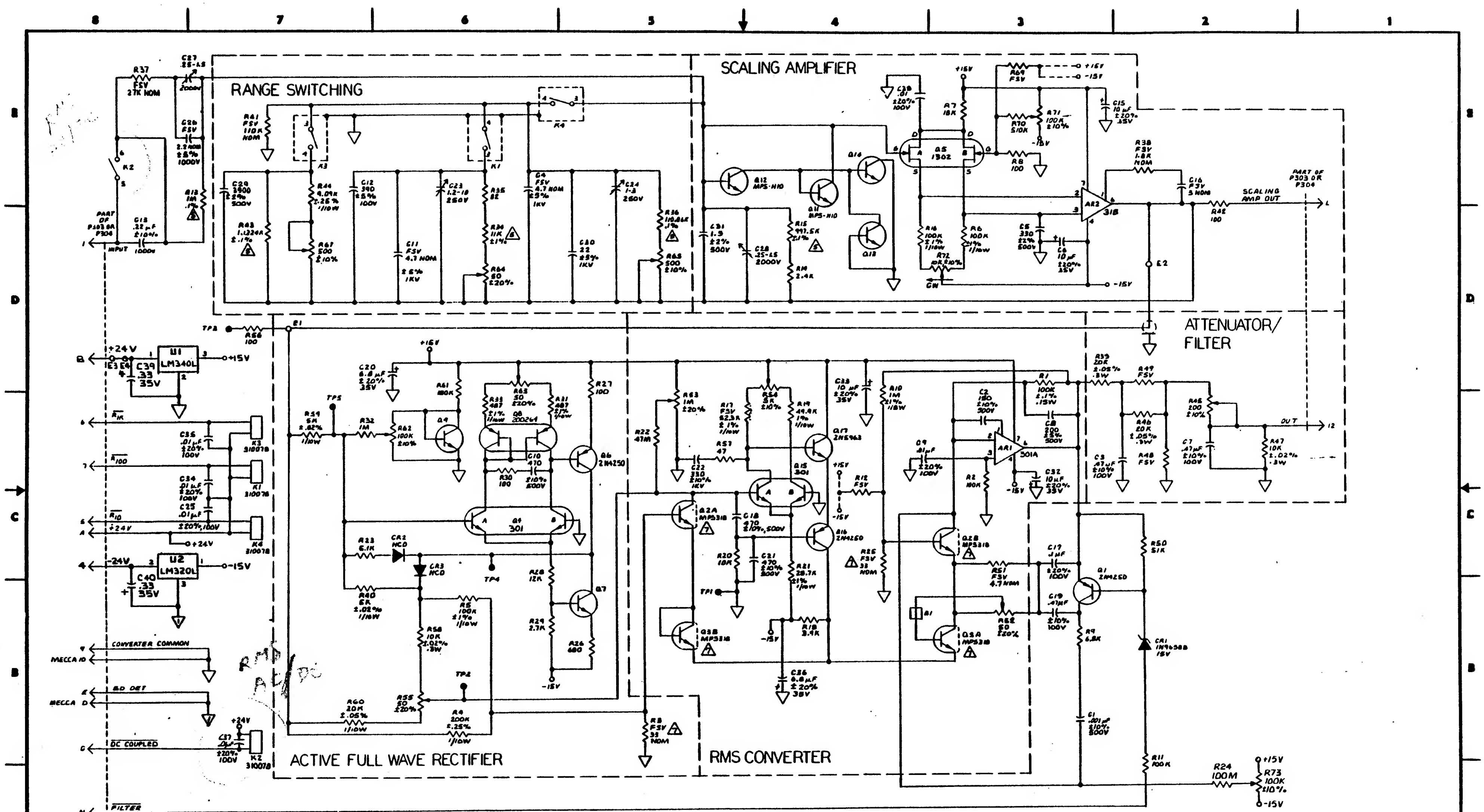
NOTES: UNLESS OTHERWISE SPECIFIED

DANA LABORATORIES INC. IRVINE, CALIFORNIA

P.C. CARD ASSY. R.M.S CONVERTER

SIZE	CODE IDENT NO	DWG NO	REV
D	21793	401618	K

SHEET 7 OF 8



△2 Q2, Q3, R3, AND R25 ARE LOGIC TRANSISTOR KIT 403865

△5 R13, R15, R34, R36, AND R43 ARE RESISTORSET 010721

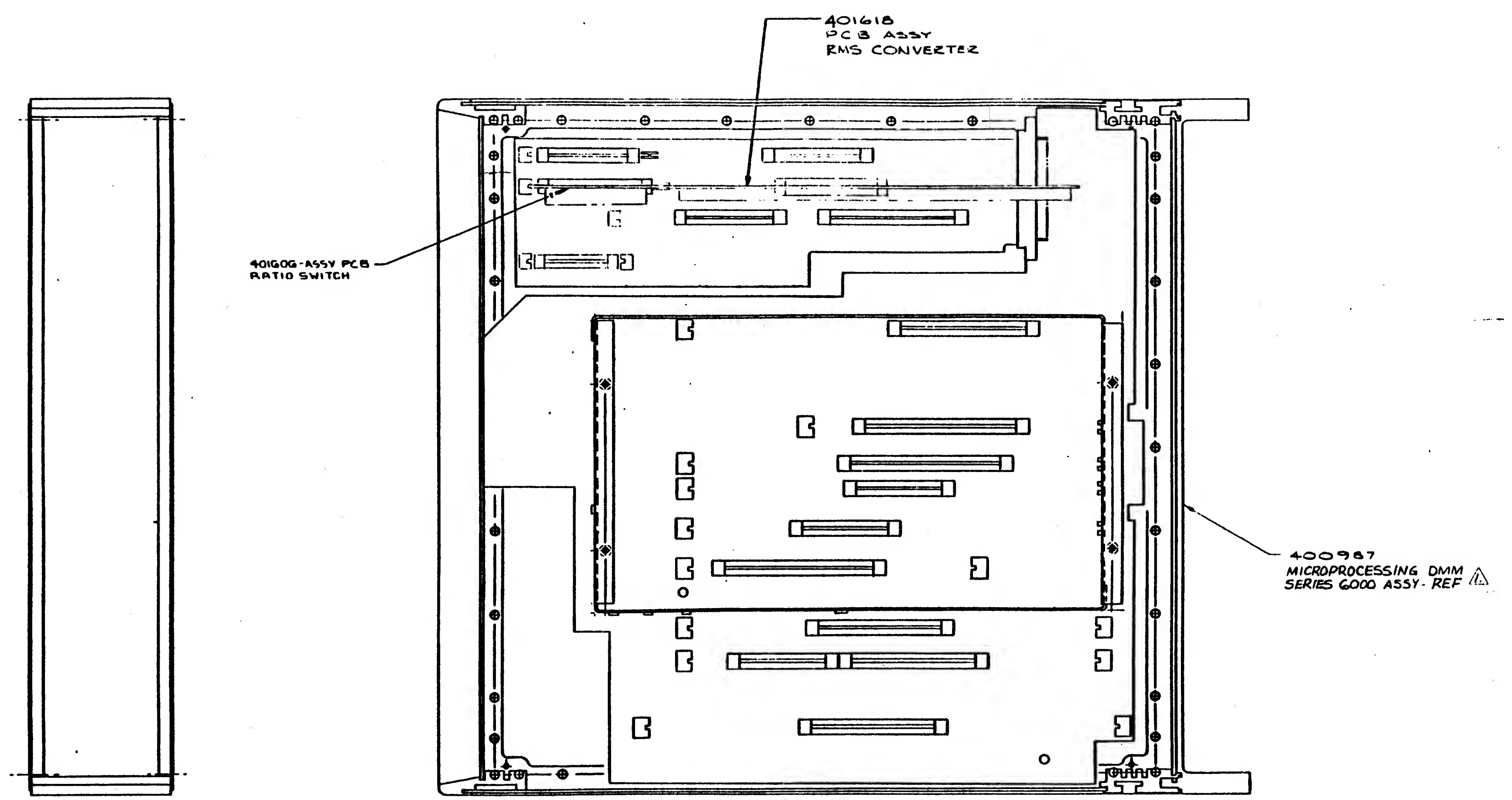
4. TRANSISTORS ARE 200200
3. DIODES ARE IN916B
2. CAPACITORS ARE IN pF
1. RESISTORS ARE IN OHMS, ±5%, 1/4W

NOTES: UNLESS OTHERWISE SPECIFIED

SCHEMATIC-
RMS CONVERTER

SIZE	CODE IDENT NO	DWG NO.	REV
D	21793	431618	D

SCALE | SHEET 1 OF 1



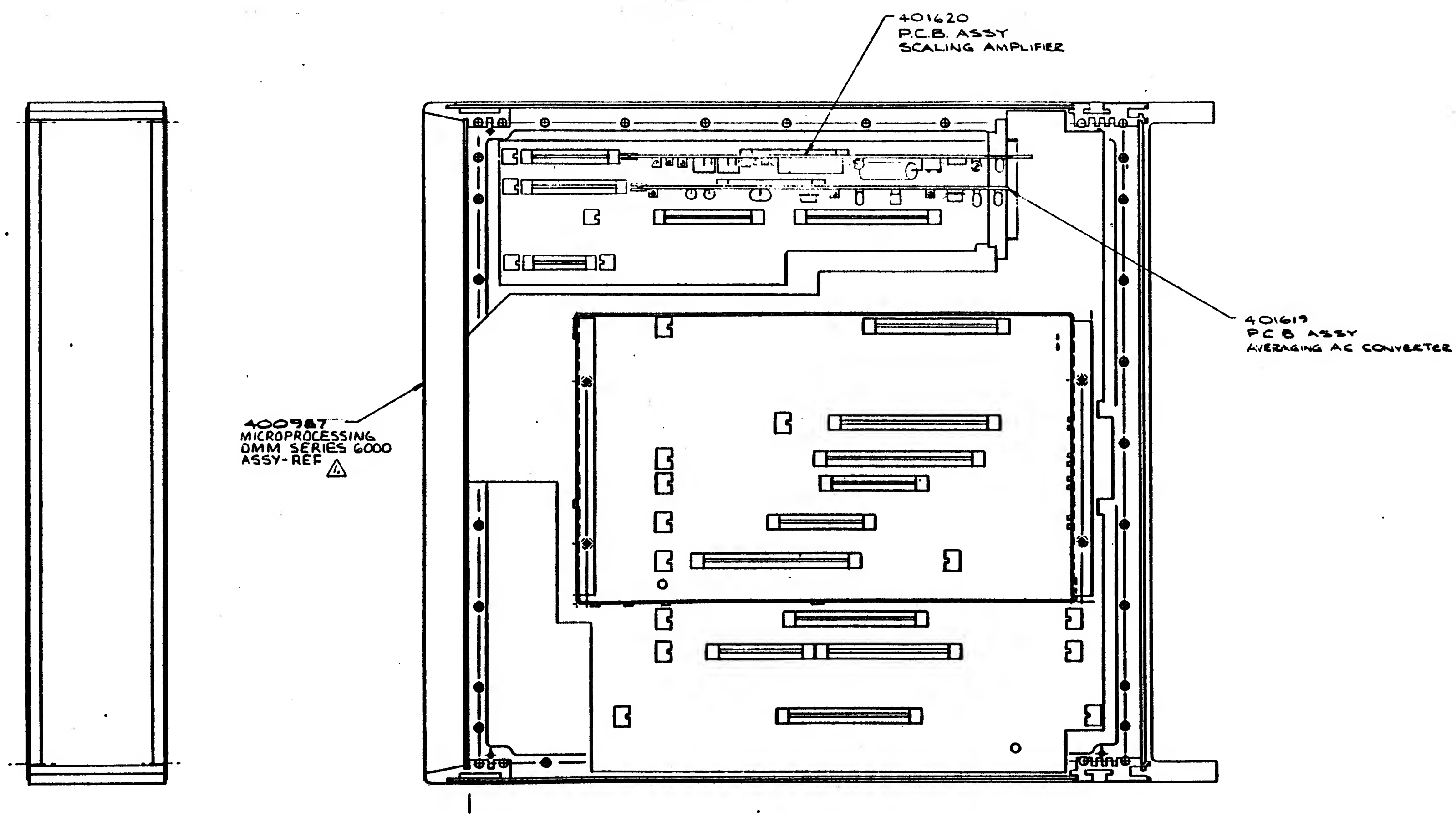
NOTES: UNLESS OTHERWISE SPECIFIED

1. COVERS AND OTHER P.C.B ASSY'S NOT SHOWN FOR CLARITY.
2. ASSEMBLE PER DANA WORKMANSHIP MANUAL

AC RATIO
OPTION ASSY

SIZE	CODE IDENT NO	DWG NO.	REV
D	21793	404026	E

SCALE N/C SHEET 1 OF 2



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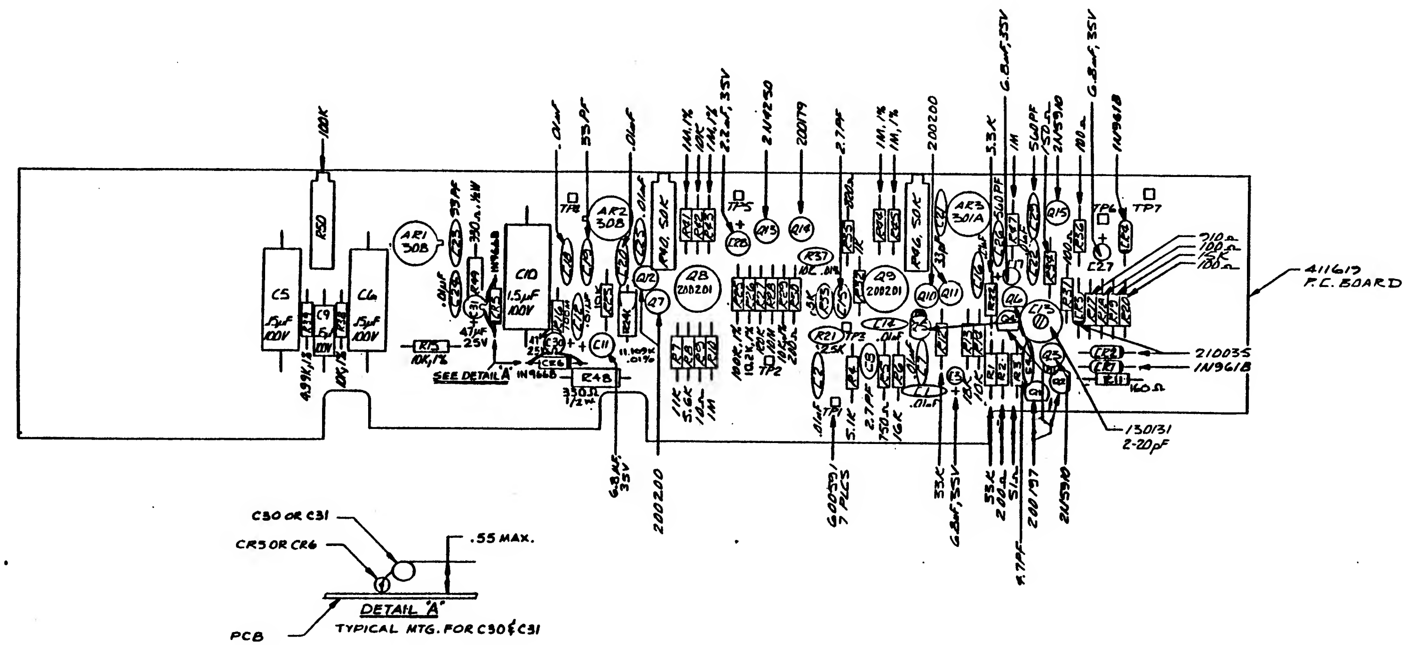
2. ASSEMBLE PER DANA WORKMANSHIP MANUAL
1. COVERS AND OTHER P C B ASSY'S NOT SHOWN FOR CLARITY.

NOTES: UNLESS OTHERWISE SPECIFIED

AC CONVERTER GROUP
OPTION ASSY

SIZE	CODE IDENT NO	DWG NO.	REV
D	21793	404028	A

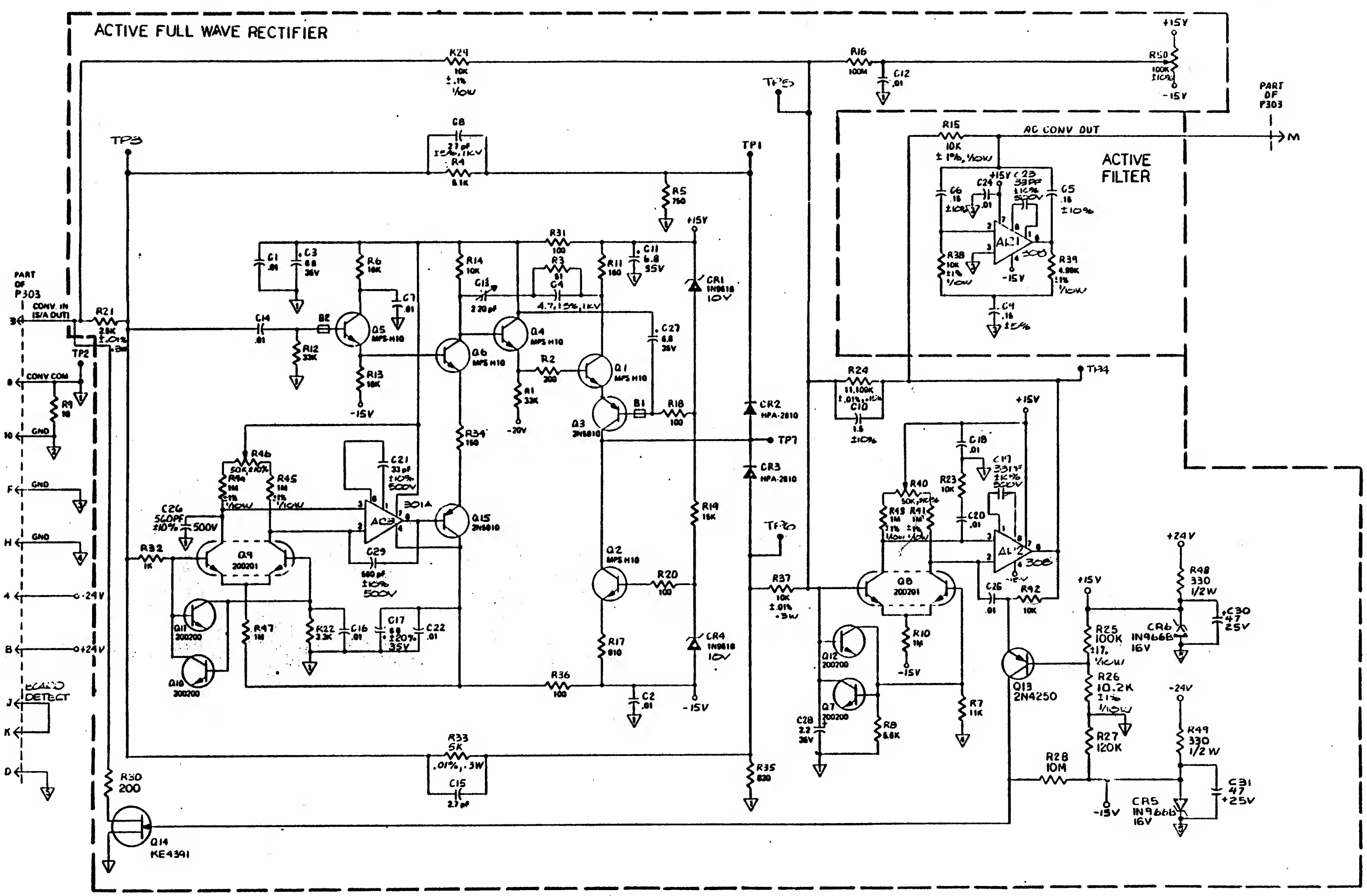
SHEET 1 OF 2



NOTES: UNLESS OTHERWISE SPECIFIED
1. ASSY PROCESSES & PROCEDURES TO CONFORM TO DANA WORKMANSHIP STANDARDS.
2. REF SCHEMATIC 431619.

PCB. ASSY
AVERAGING
AC CONVERTER

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	401619	F
SCALE 2X1		SHEET 1 OF 6	

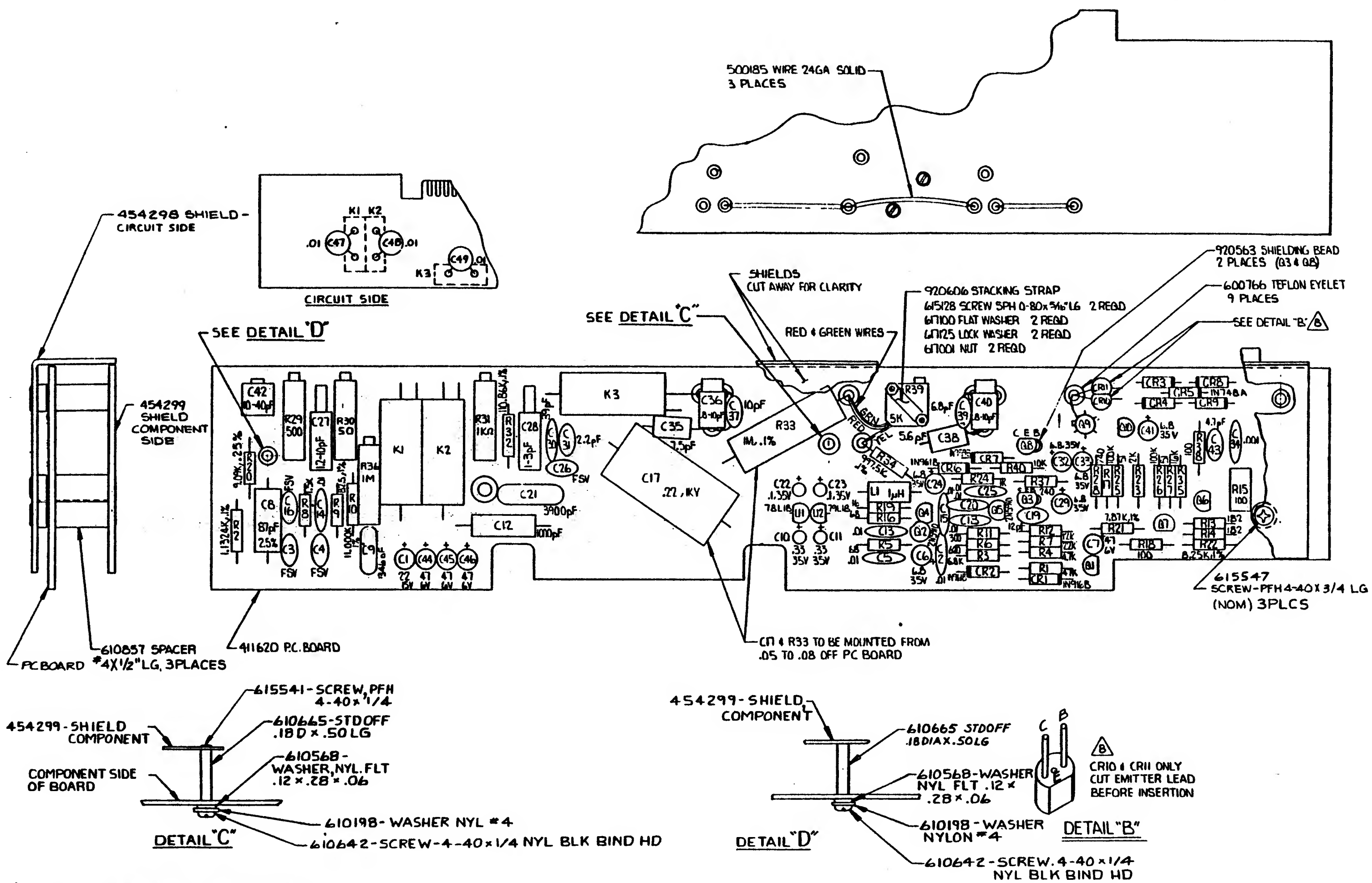


NOTES UNLESS OTHERWISE SPECIFIED
1. RESISTORS ARE IN OHMS ±5% 1/4W.
2. CAPACITORS ARE IN µF, ±20%, 100V.
3. ASSY 431619

TP3	
R50	
Q15	
C30	
C27	
B2	
AR3	
LAST	NOT USED
DESIGNATORS	

SCHEMATIC - AC CONVERTER, AVERAGING

SIZE	CODE IDENT NO	DWG NO.	REV
D	21793	431619	D

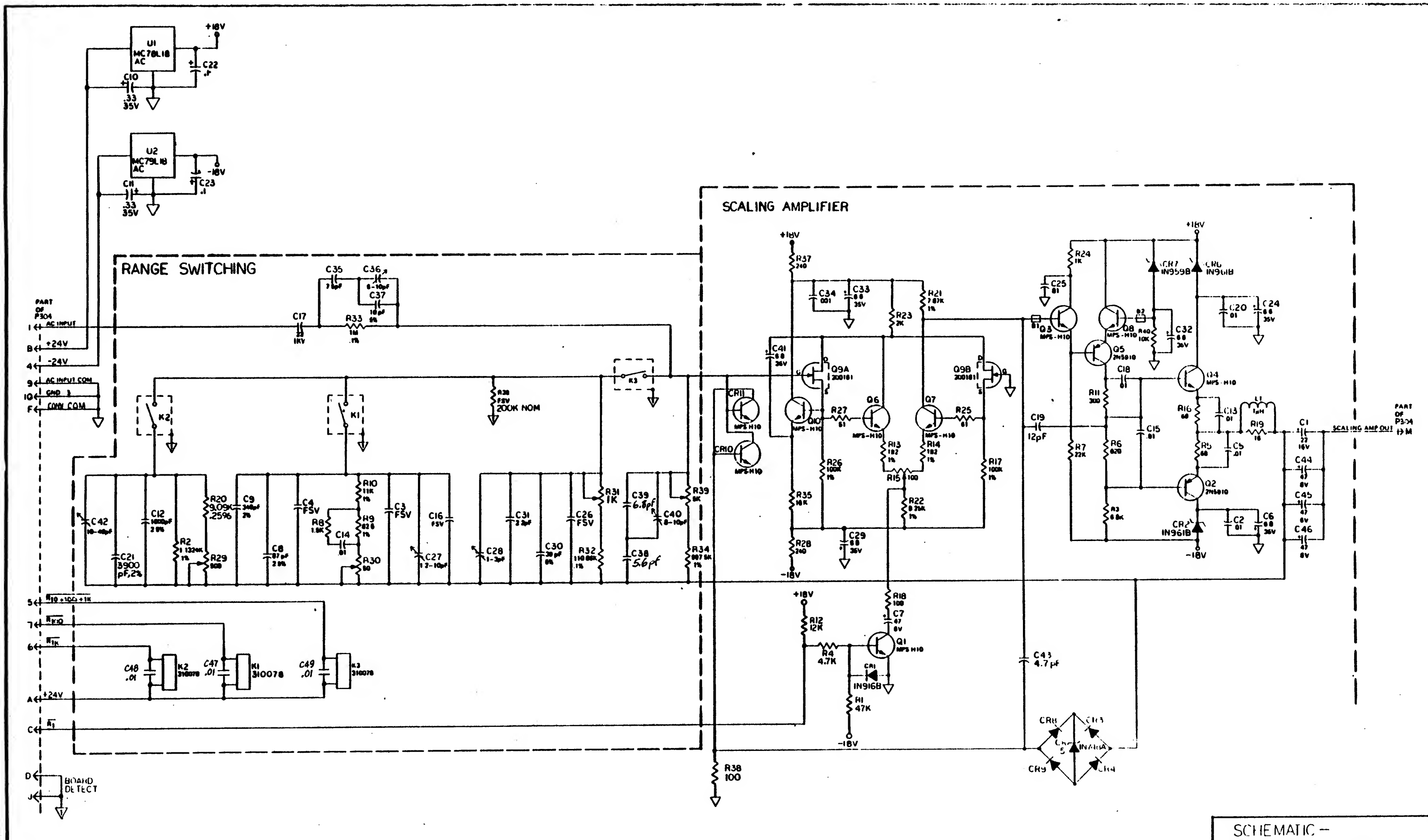


⚠9 FSV CAPACITORS, IF REQD, TO BE DONE DURING CHECK OUT
⚠8 CR10 & CR11 ARE MPS-H10, SEE DETAIL "B"
7. ALL RELAYS ARE 310078
6. ALL TRANSISTORS ARE MPS-H10
5. DIODES (CR3 & 4) AND (CR8 & 9) ARE MATCHED PAIRS OF HP5082-2800
4. ALL CAPACITORS ARE μF
3. ALL RESISTORS ARE IN OHMS, ±5%, 1/4W
2. REFERENCE SCHEMATIC NO. 431620
1. ASSEMBLY PROCESSES & PROCEDURES TO CONFORM TO DANA WORKMANSHIP STANDARDS

NOTES: UNLESS OTHERWISE SPECIFIED

ASSY
SCALING AMPLIFIER

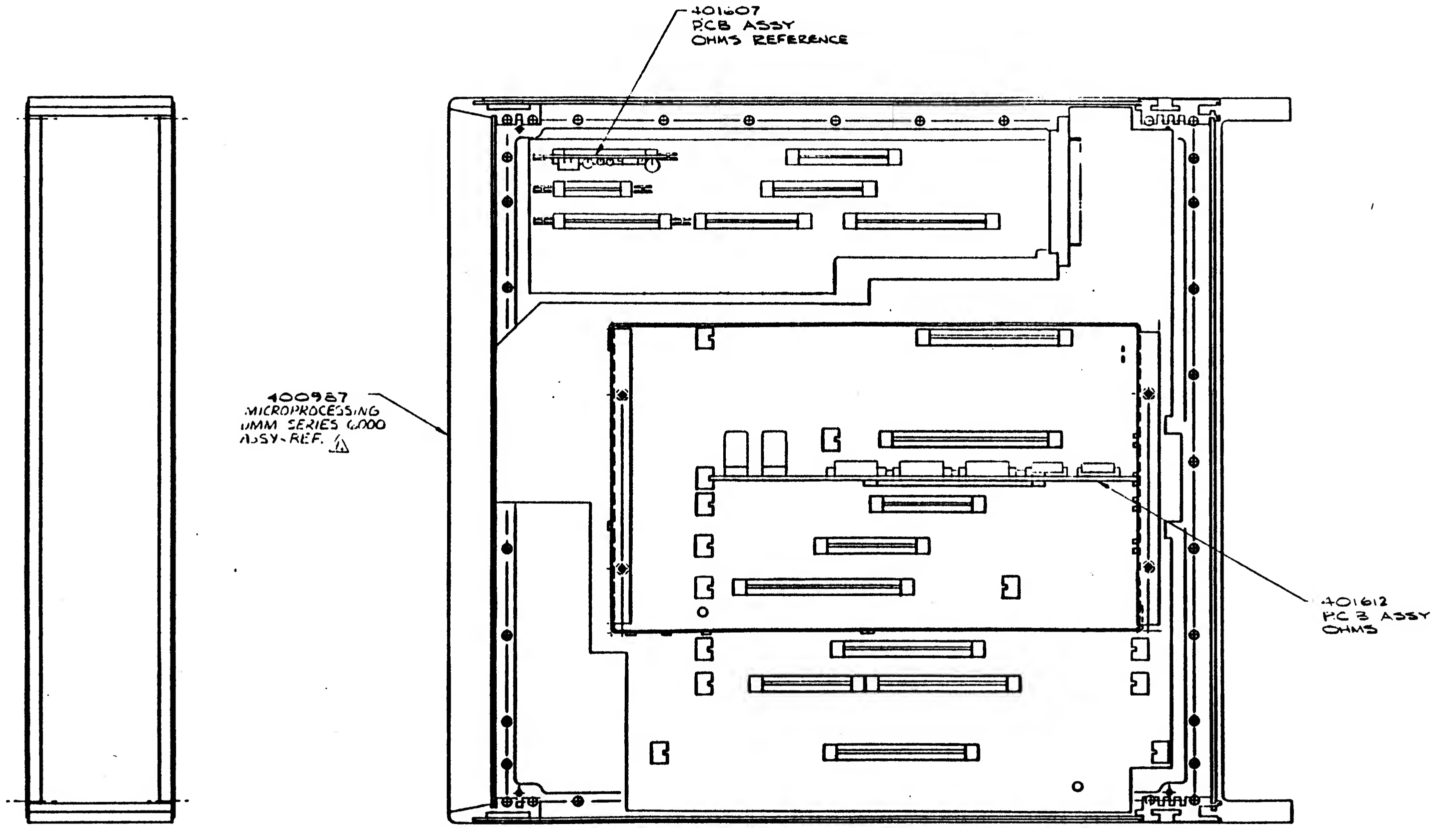
SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	401620	K
SCALE: 2/1		SHEET 1 OF 8	



4. CR3 AND CR4, CR8 AND CR9 ARE MATCHED PAIRS OF HP5082-2800 DIODES
3. ASSEMBLY 401620
2. CAPACITORS ARE IN μF
1. RESISTORS ARE IN OHMS, ±5%, 1/4W

NOTES UNLESS OTHERWISE SPECIFIED

SCHEMATIC – SCALING AMPLIFIER			
SIZE	CODE IDENT NO	DWG NO	REV
D	21793	431620	D

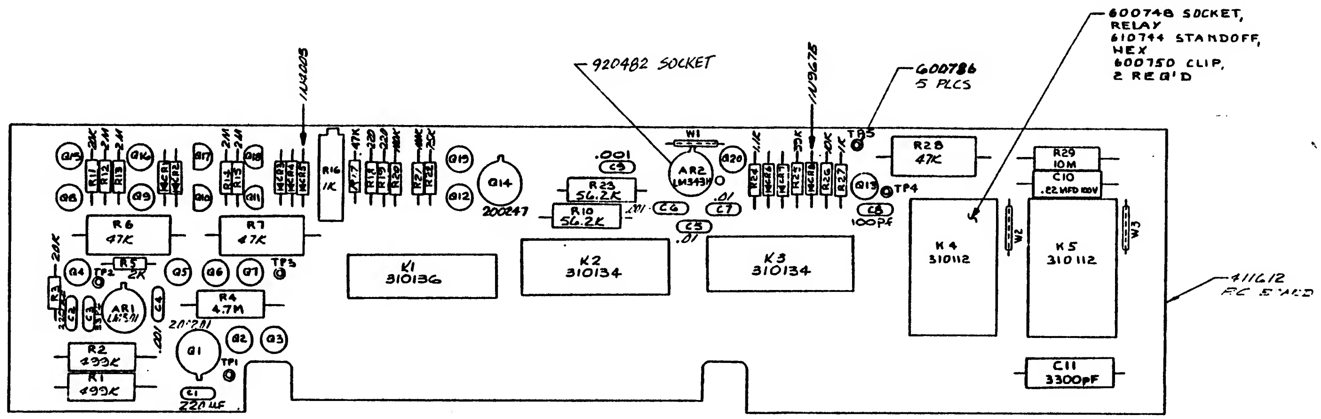


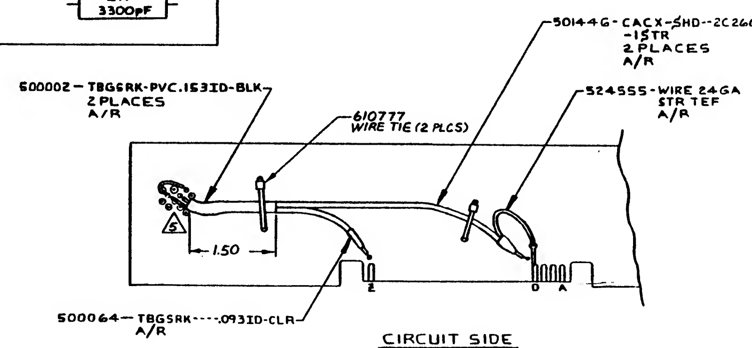
NOTES: UNLESS OTHERWISE SPECIFIED

2. ASSEMBLE PER DANA WORKMANSHIP MANUAL
1. COVERS AND OTHER PCB. ASSY'S NOT SHOWN FOR CLARITY

OHMS OPTION ASSY

SIZE	CODE IDENT NO	DWG NO.	REV
D	21793	404023	B
SCALE		SHEET 1 OF 2	





CIRCUIT SIDE
SCALE: NONE

7. SOLDER JOINTS AT K5-10, K5-14, AND K5-15 MUST NOT TOUCH EDGE OF HOLES DRILLED THROUGH PC BOARD.

6. ALL COMPONENT LEADS IN THE ROUTING PATH OF THE CIRCUIT-SIDE WIRING SHALL BE CLIPPED SO AS TO ASSURE THAT PUNCTURE OF WIRE COVERING WILL NOT OCCUR.

5. SOLDER SHIELDS TOGETHER BEFORE APPLYING SHRINK SLEEVE.

4. ALL DIODES ARE IN9168 (P/N 211083)

3. TRANSISTOR NO. ARE
200200 - Q2,3,8,9,12,13,16,19
200368 - Q5,6,7
200158 - Q10,11,17,18
200088 - Q15,19,20

2. REF. SCHEMATIC 431612.

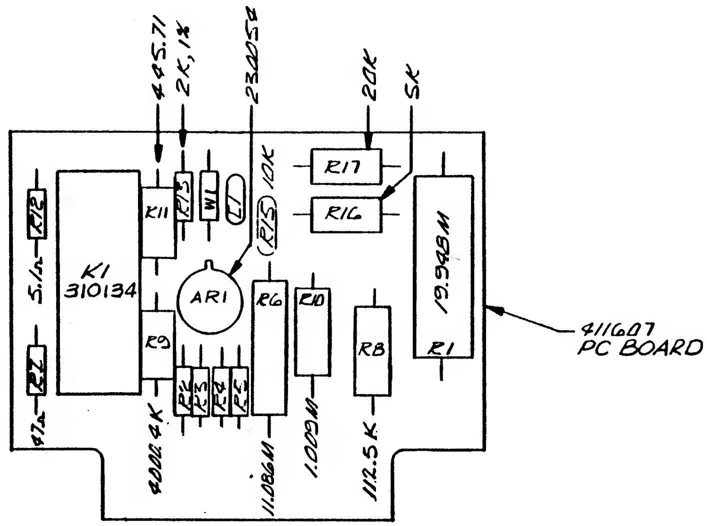
1. ASSY PROCESSES & PROCEDURES TO CONFORM TO DANA WORKMANSHIP STANDARDS.

NOTES: UNLESS OTHERWISE SPECIFIED

PCB ASSY
OHMS

SIZE	CODE IDENT NO	DWG NO	REV
D	21793	401612	R

SCALE 1/1 SHEET 1 OF 6

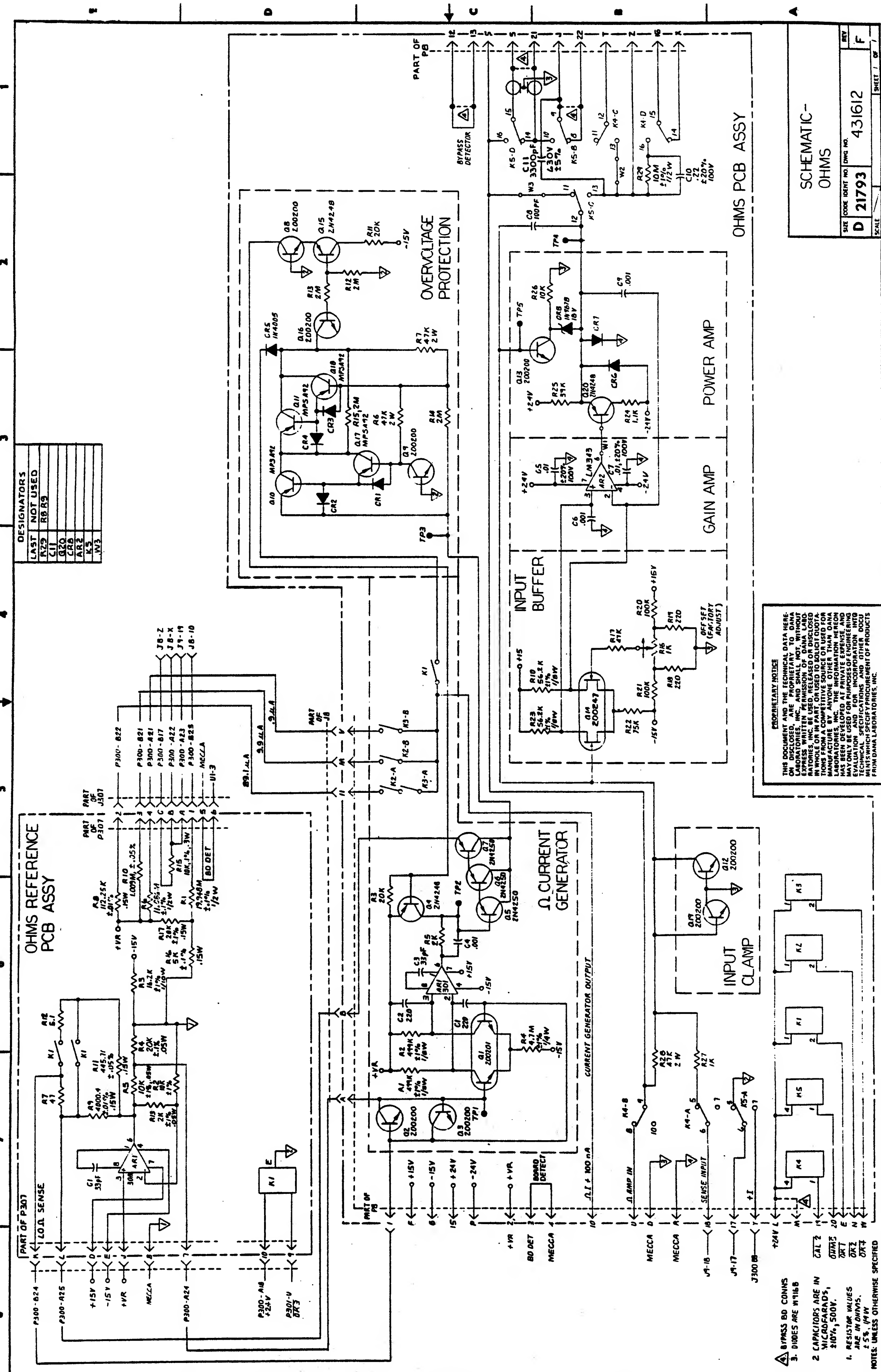


3. RESISTOR VALUES ARE IN OHMS, ± 5%, 1/4 W
2. REF SCHEMATIC NO. 431607.
1. ASSY PROCEDURES & PROCESSES TO CONFORM TO DANA WORKMANSHIP STANDARDS

NOTES: UNLESS OTHERWISE SPECIFIED

P.C. BOARD ASSY
OHMS REFERENCE

SIZE	CODE IDENT NO	DWG NO.	REV
C	21793	401607	D
SCALE 2X1		SHEET 1 OF 3	


SCHEMATIC- OHMS
SIZE D
CODE IDENT NO. 21793
DWG NO. 431612
REV F
SHEET 1 OF 1
OHMS PCB ASSY
OHMS REFERENCE PCB ASSY
OVERVOLTAGE PROTECTION
POWER AMP
GAIN AMP
INPUT BUFFER
INPUT CLAMP
Ω CURRENT GENERATOR
CURRENT GENERATOR OUTPUT
BYPASS DETECTOR
DESIGNATORS
LAST | NOT USED
R29 | R8 R9
C11
Q20
CR8
AR2
K5
W3
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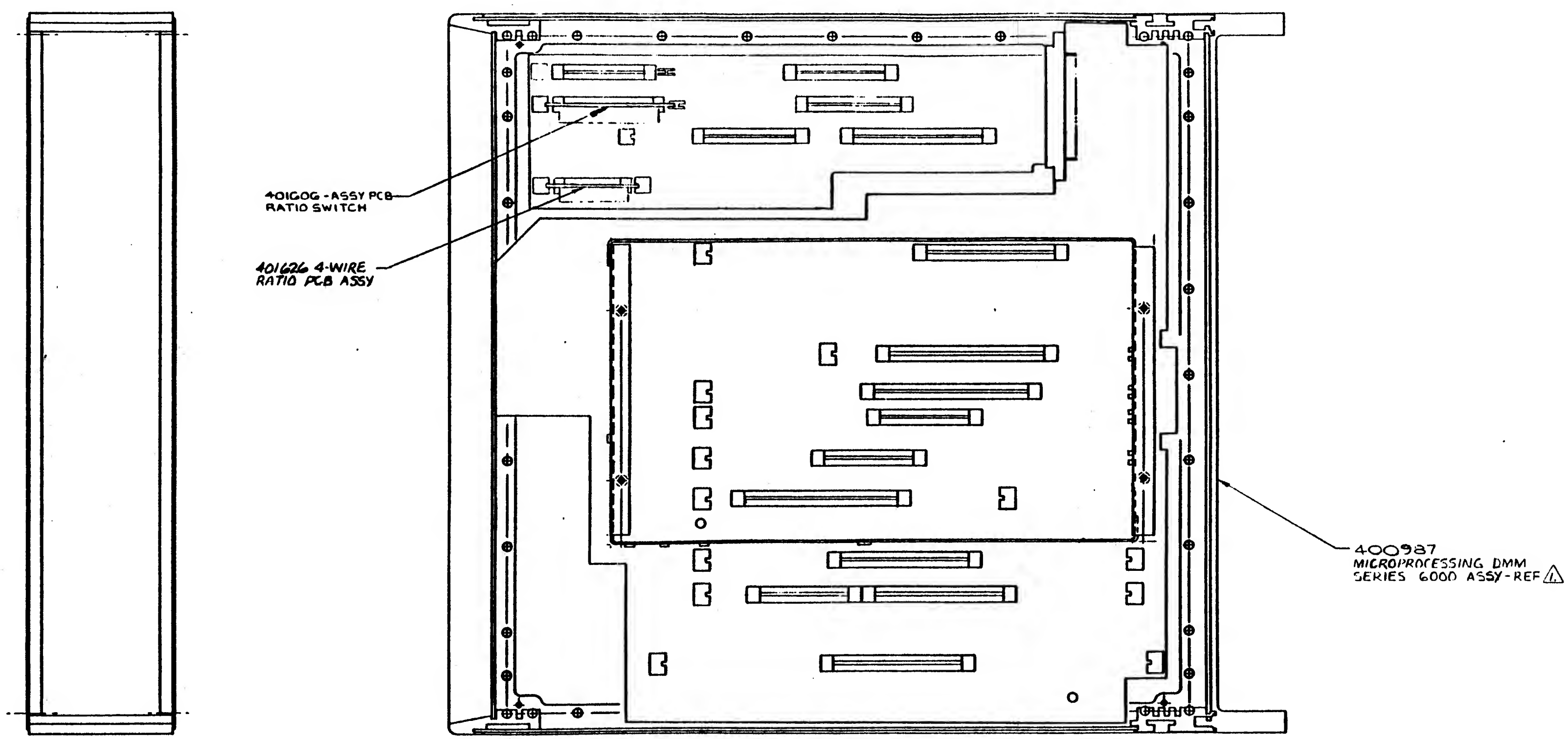
NOTES: UNLESS OTHERWISE SPECIFIED
1. RESISTOR VALUES ARE IN OHMS, ±5%, 1/4W
2. CAPACITORS ARE IN MICROFARADS, ±10%, 500V.
3. DIODES ARE IN916B
BYPASS BD CONNS



NOTES: UNLESS OTHERWISE SPECIFIED

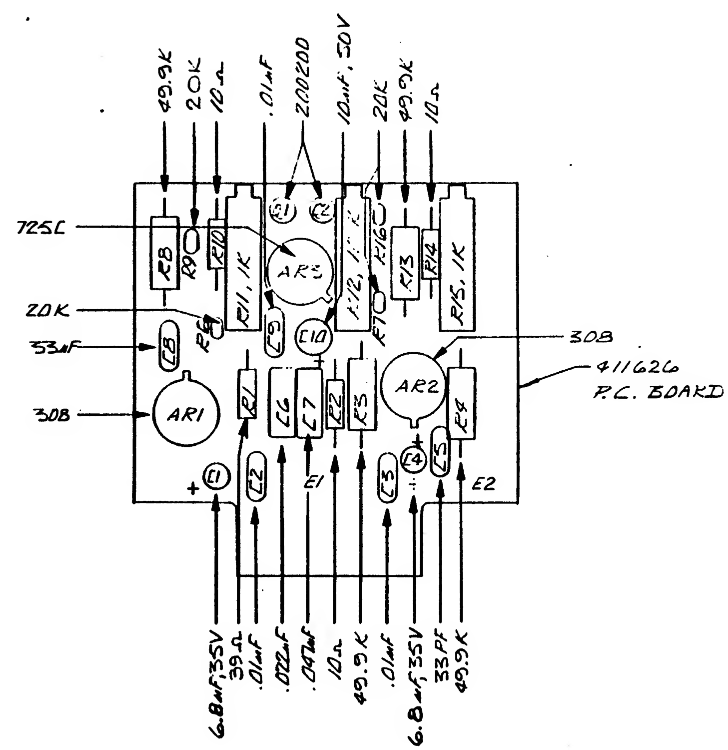
△1 COVERS AND OTHER PCB ASSY'S NOT SHOWN FOR CLARITY.

2. ASSEMBLE PER DANA WORKMANSHIP MANUAL

4 WIRE RATIO OPTION ASSY

SIZE	CODE IDENT NO	DWG NO.	REV
D	21793	404025	D

SHEET 1 OF 2

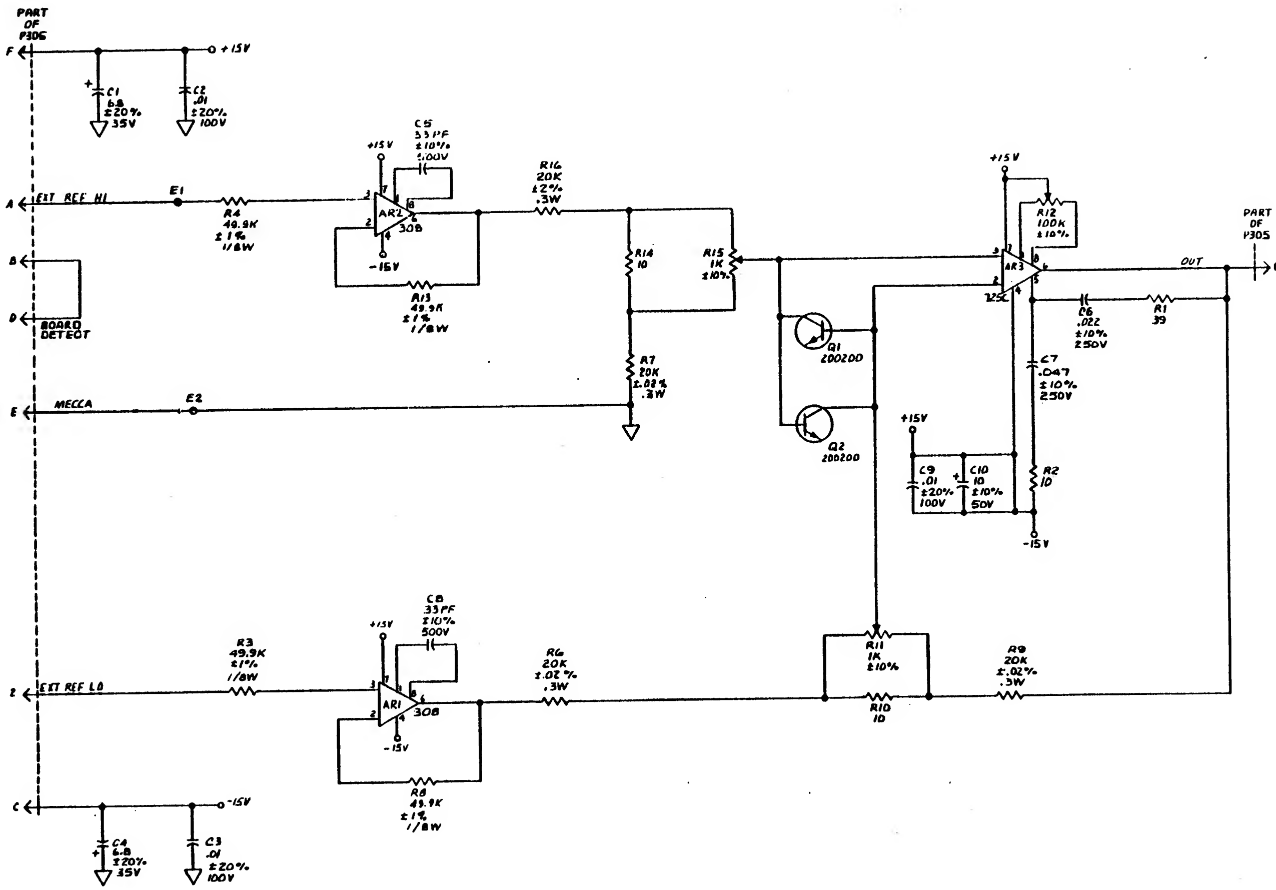


NOTES: UNLESS OTHERWISE SPECIFIED

1. ASSY PROCESSES & PROCEDURES TO CONFORM TO DANA WORKMANSHIP STANDARDS.
2. REF SCHEMATIC 431626.
3. RESISTORS ARE IN OHMS, ±5%, 1/4W.

PCB ASSY
4 WIRE RATIO

SIZE	CODE IDENT NO	DWG NO.	REV
C	21793	411626	B
SCALE 2 X 1		SHEET 1 OF 3	



NOTES: UNLESS OTHERWISE SPECIFIED

1. RESISTOR VALUES ARE IN OHMS, ±5%, 1/4W
2. CAPACITOR VALUES ARE IN MICROFARADS

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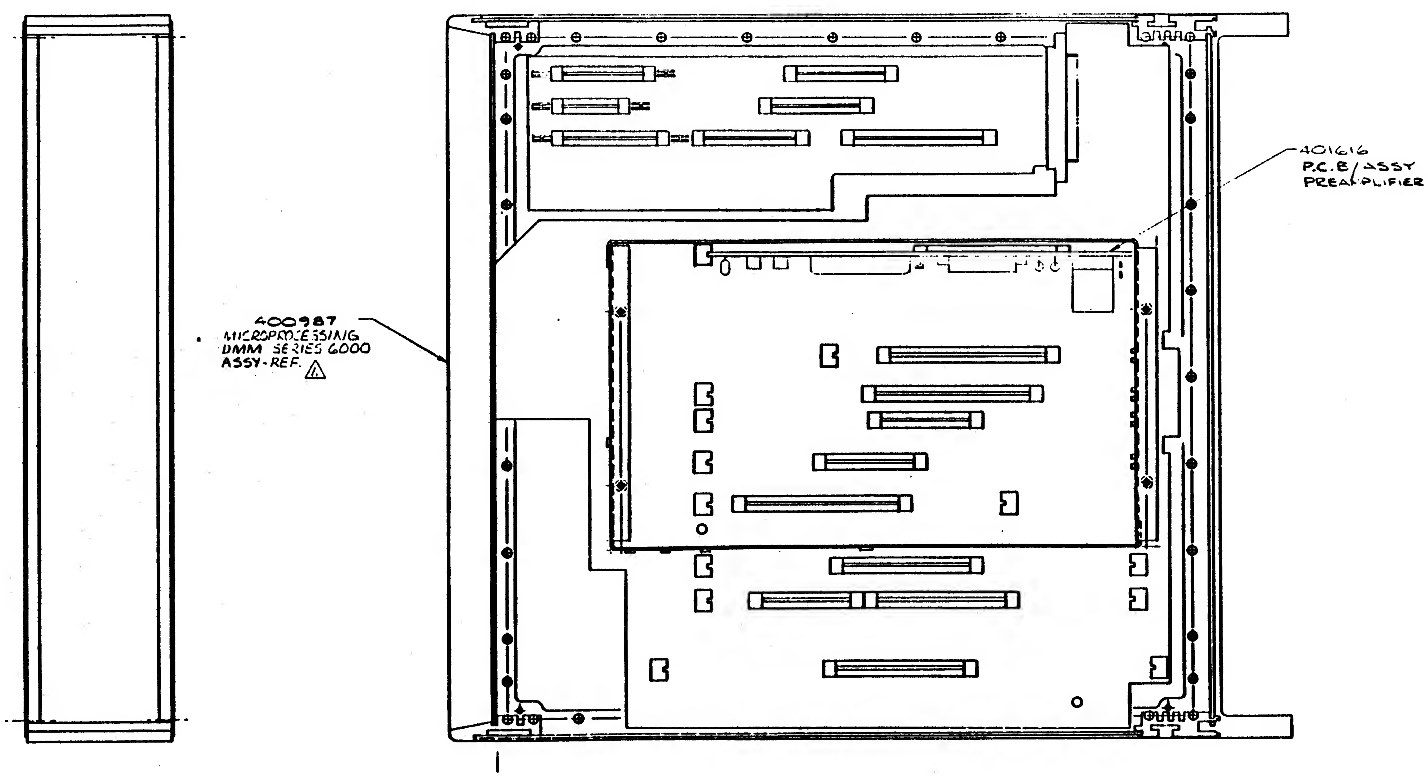
SCHEMATIC - 4 WIRE RATIO

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	431626	A

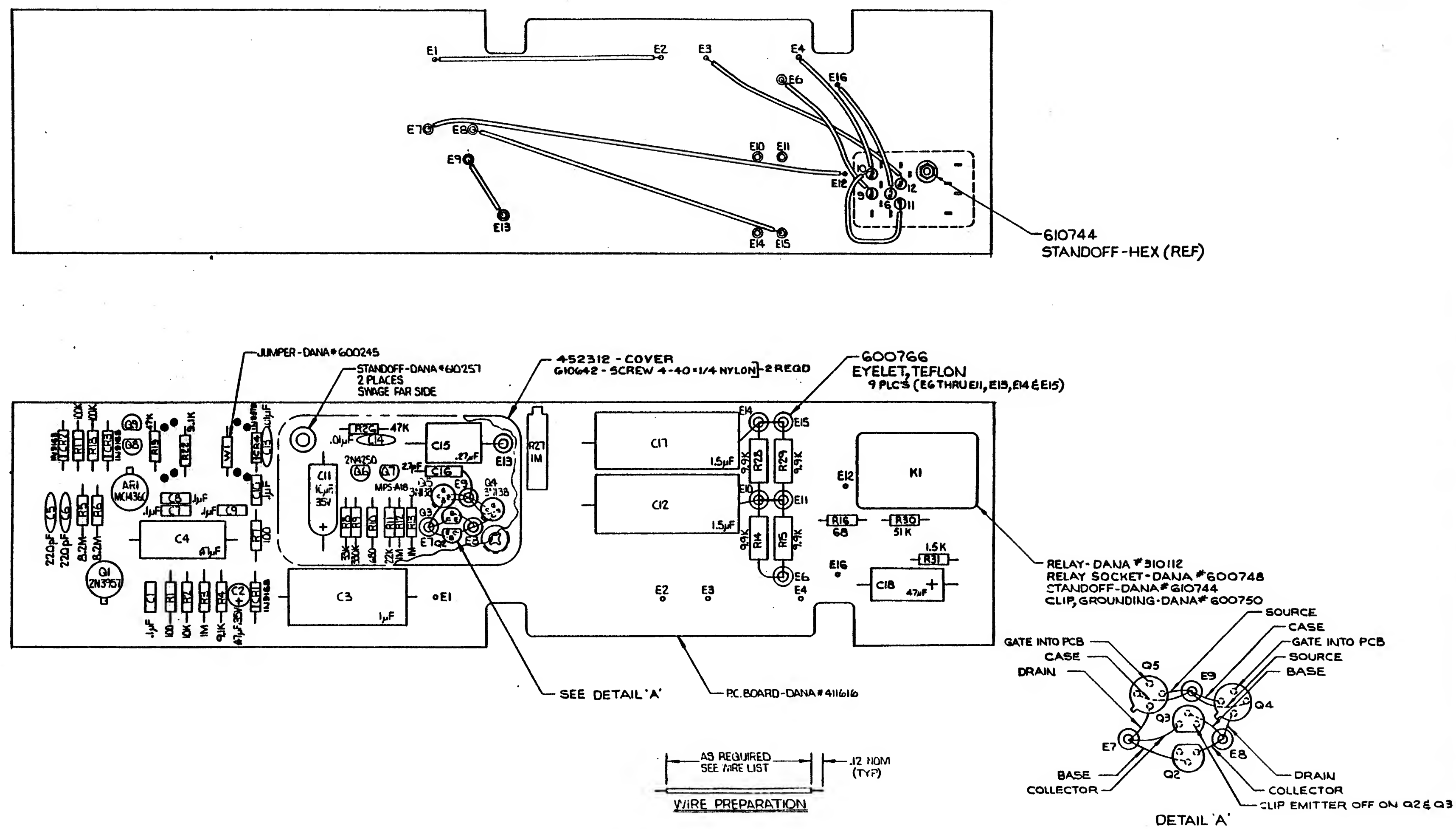
SCALE — SHEET 1 OF 1



NOTES: UNLESS OTHERWISE SPECIFIED

1. COVERS AND OTHER PCB ASSY'S NOT SHOWN FOR CLARITY.
2. ASSEMBLE PER DANA WORKMANSHIP MANUAL.

PREAMPLIFIER OPTION ASSY			
SIZE	CODE IDENT NO	DWG NO.	REV
D	21793	404024	B
SCALE		SHEET 1 OF 2	

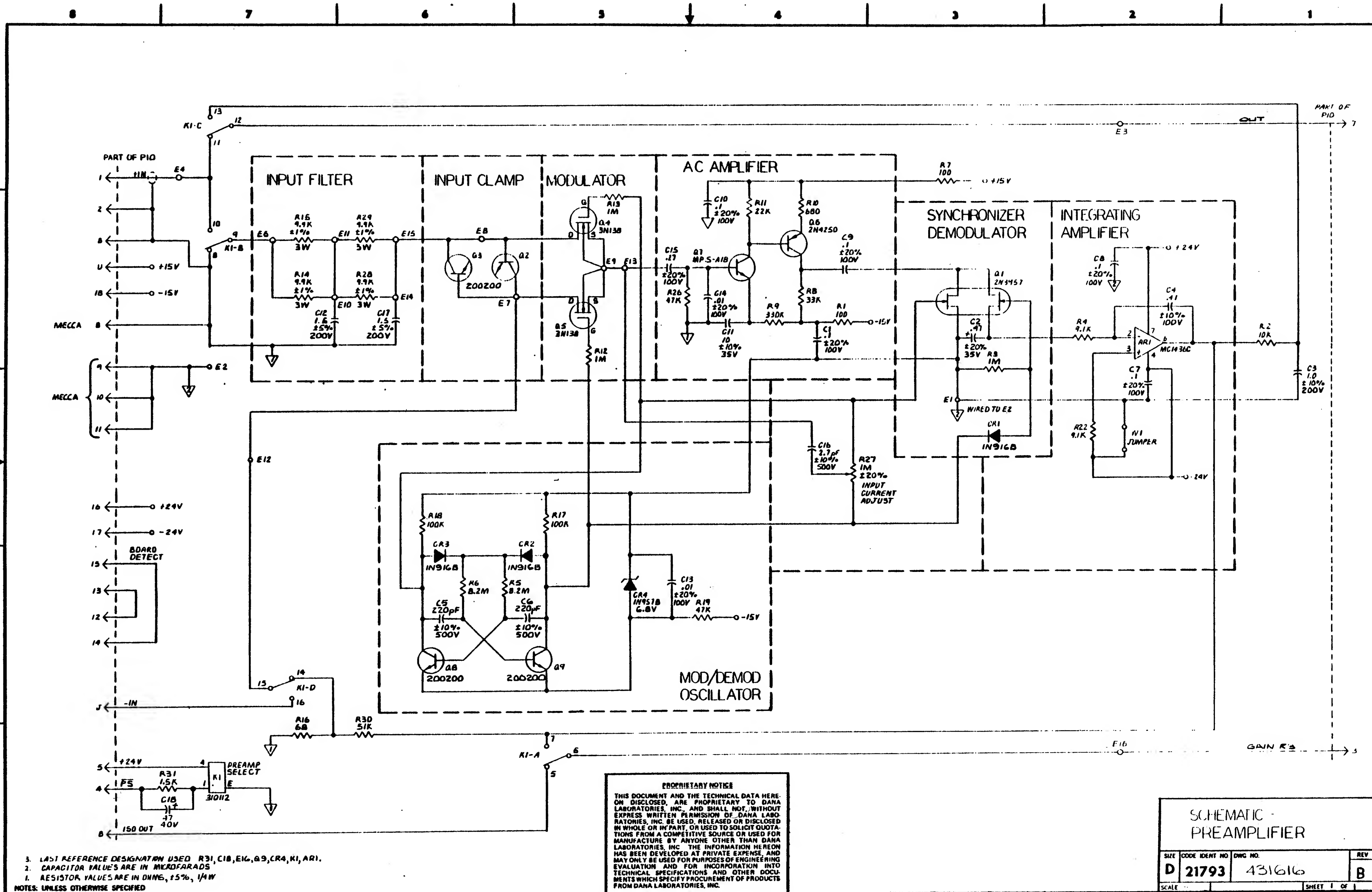


5. TRANSISTORS ARE DANA #200200.
4. DIODES ARE IN9168 (211083).
3. RESISTORS ARE IN OHMS, ±5%, 1/4 W.
2. REFERENCE SCHEMATIC NUMBER 431616.
1. ASSEMBLY PROCEEDURES AND PROCESSES TO CONFORM TO DANA WORKMANSHIP MANUAL.

NOTES: UNLESS OTHERWISE SPECIFIED

P.C. BOARD ASSEMBLY —
PREAMPLIFIER

SIZE	CODE IDENT NO	DWG NO.	REV
D	21793	401616	D
SCALE 7/1		SHEET 1 OF 5	

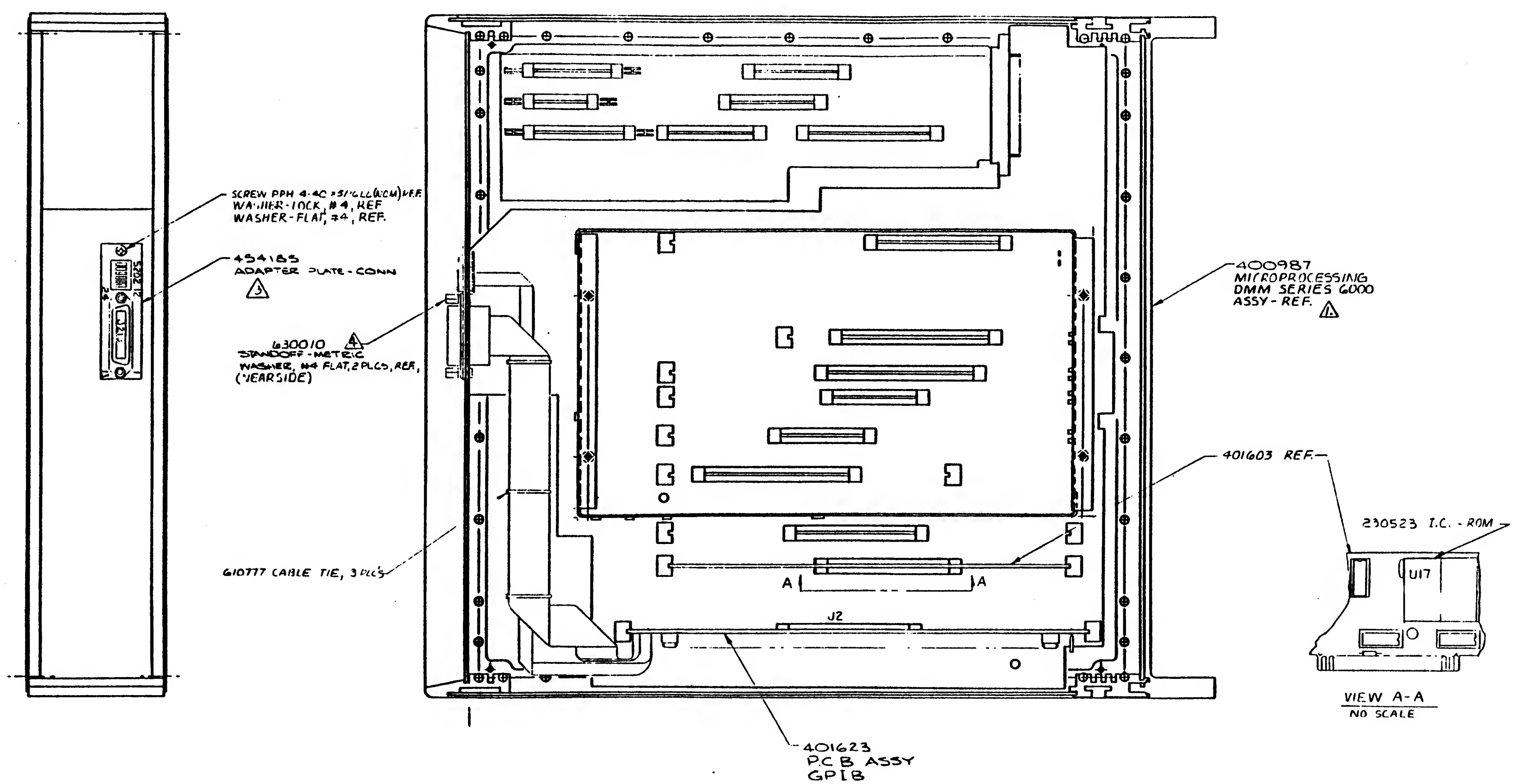


SCHEMATIC - PREAMPLIFIER

SIZE	CODE IDENT NO	DWG NO.	REV
D	21793	431616	B

SCALE — SHEET 1 OF 1

NOTES: UNLESS OTHERWISE SPECIFIED
1. RESISTOR VALUES ARE IN OHMS, ±5%, 1/4W
2. CAPACITOR VALUES ARE IN MICROFARADS
3. LAST REFERENCE DESIGNATION USED R31, C18, E16, Q9, CR4, K1, AR1.



5 FIELD INSTALLATION INSTRUCTION SHEET 980610.

4 DISCARD NUTS AND LOCKWASHERS.

3 REMOVE BUTCH PLATE 454183 BEFORE MTG CONN AND SWITCH BOARD

2 ASSEMBLE PER RACAL-DANA WORKMANSHIP MANUAL

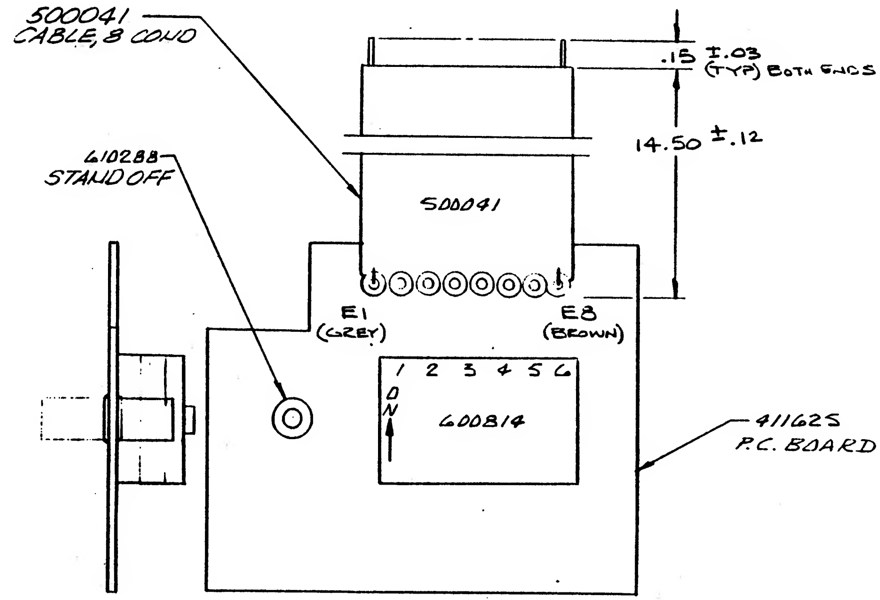
1 COVERS & OTHER PCB ASSY'S NOT SHOWN FOR CLARITY

NOTES: UNLESS OTHERWISE SPECIFIED

GPIB IEEE-488-1975
OPTION ASSY

SIZE	CODE IDENT NO	DWG NO	REV
D	21793	404017	H

SCALE: NONE SHEET 1 OF 2

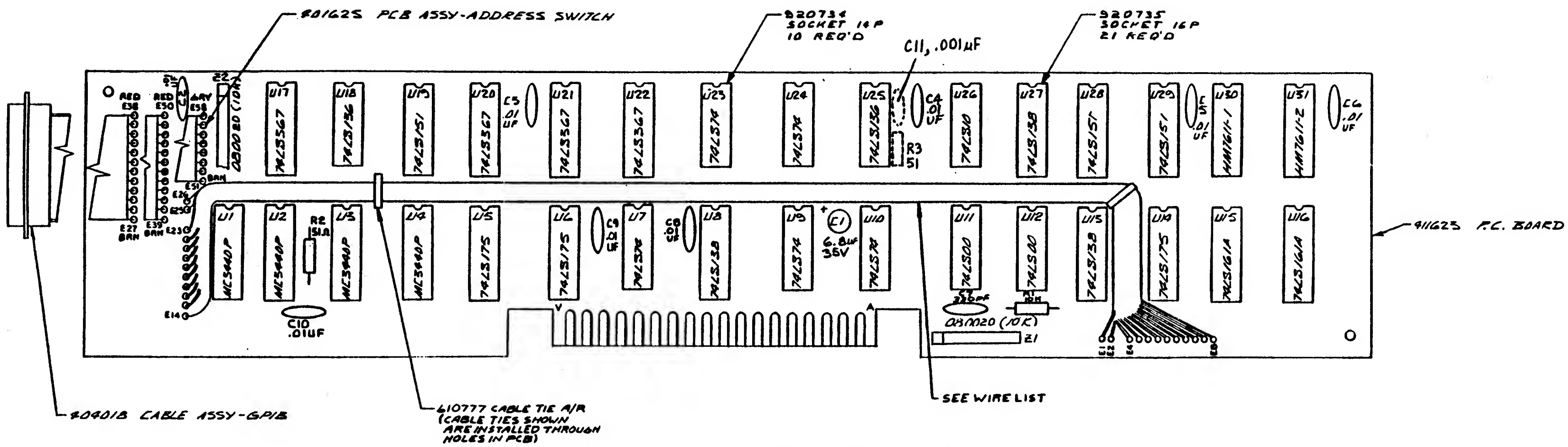


1. ASSY PROCESSES & PROCEDURES TO CONFORM TO DANA WORKMANSHIP STANDARDS.

NOTES: UNLESS OTHERWISE SPECIFIED

ASSY
GPIB ADDRESS SWITCH

SIZE	CODE IDENT NO	DWG NO.	REV
C	21793	411625	C
SCALE 2X1		SHEET 1 OF 2	



COMPONENT SIDE SHOWN

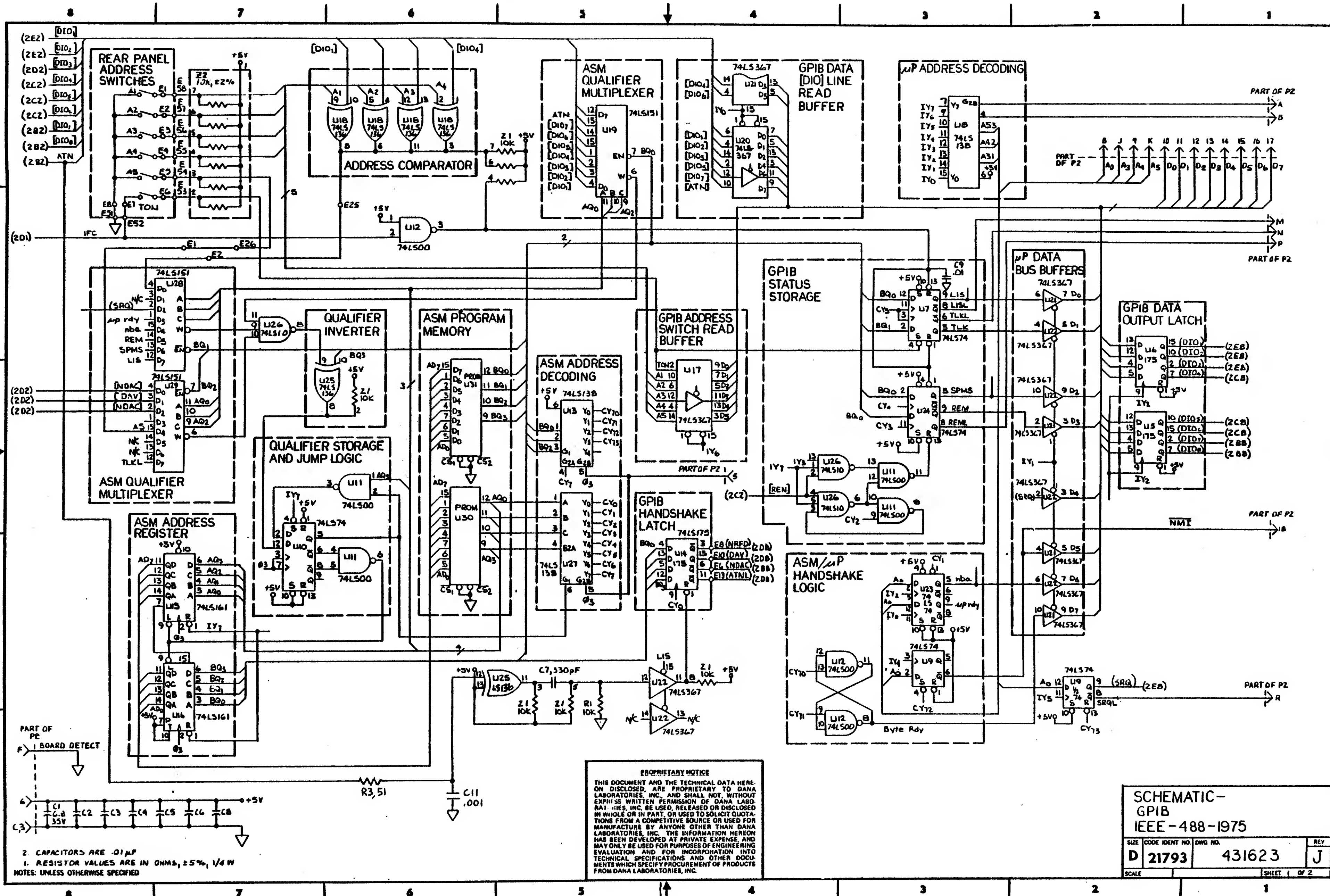
2. REF SCHEMATIC 431623.
1. ASSY PROCESSES & PROCEDURES TO CONFORM TO DANA WORKMANSHIP STANDARDS.

NOTES: UNLESS OTHERWISE SPECIFIED

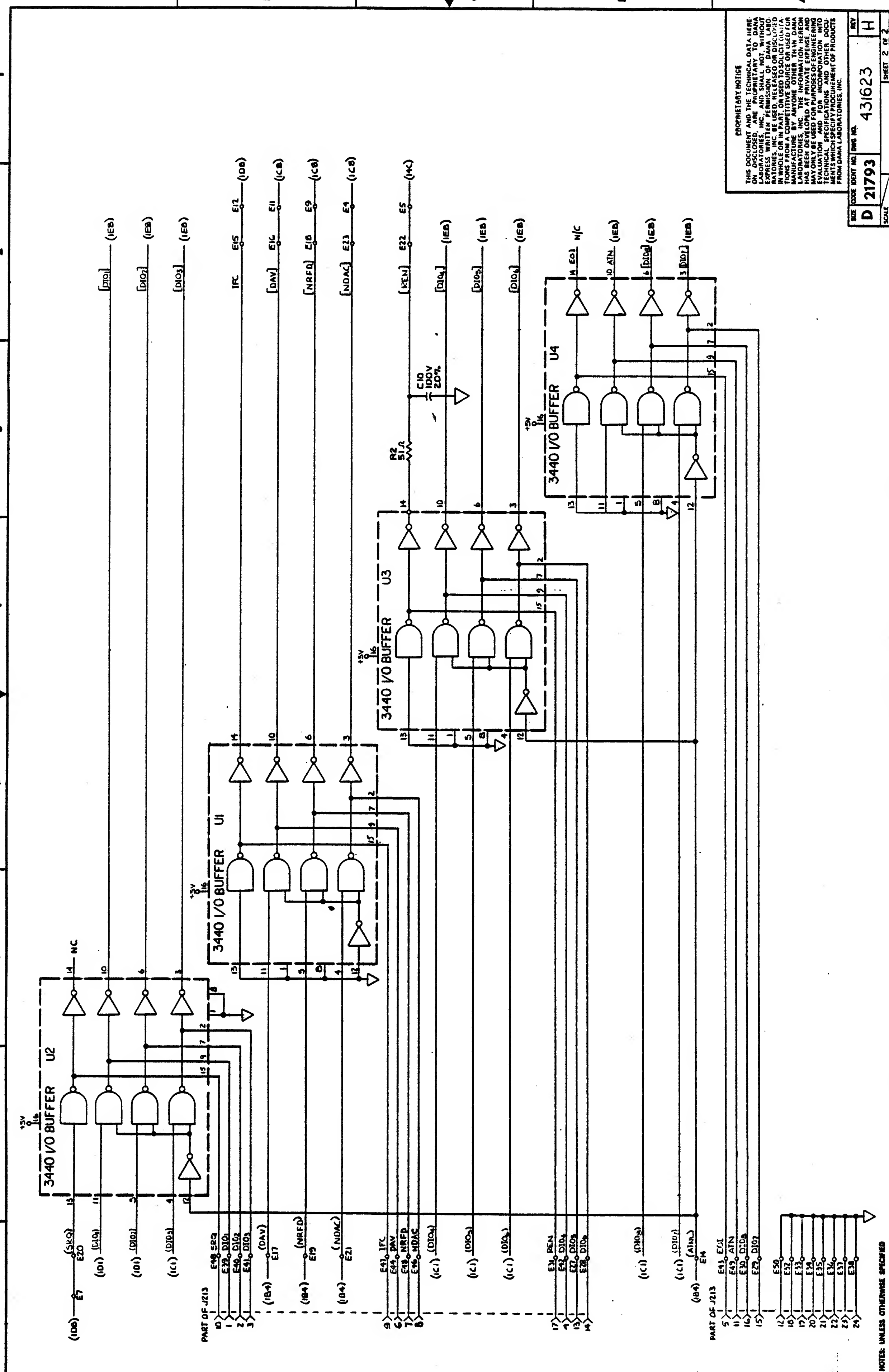
P.C. BOARD ASSY
GPIB - IEEE - 488 - 1975

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	401625	K

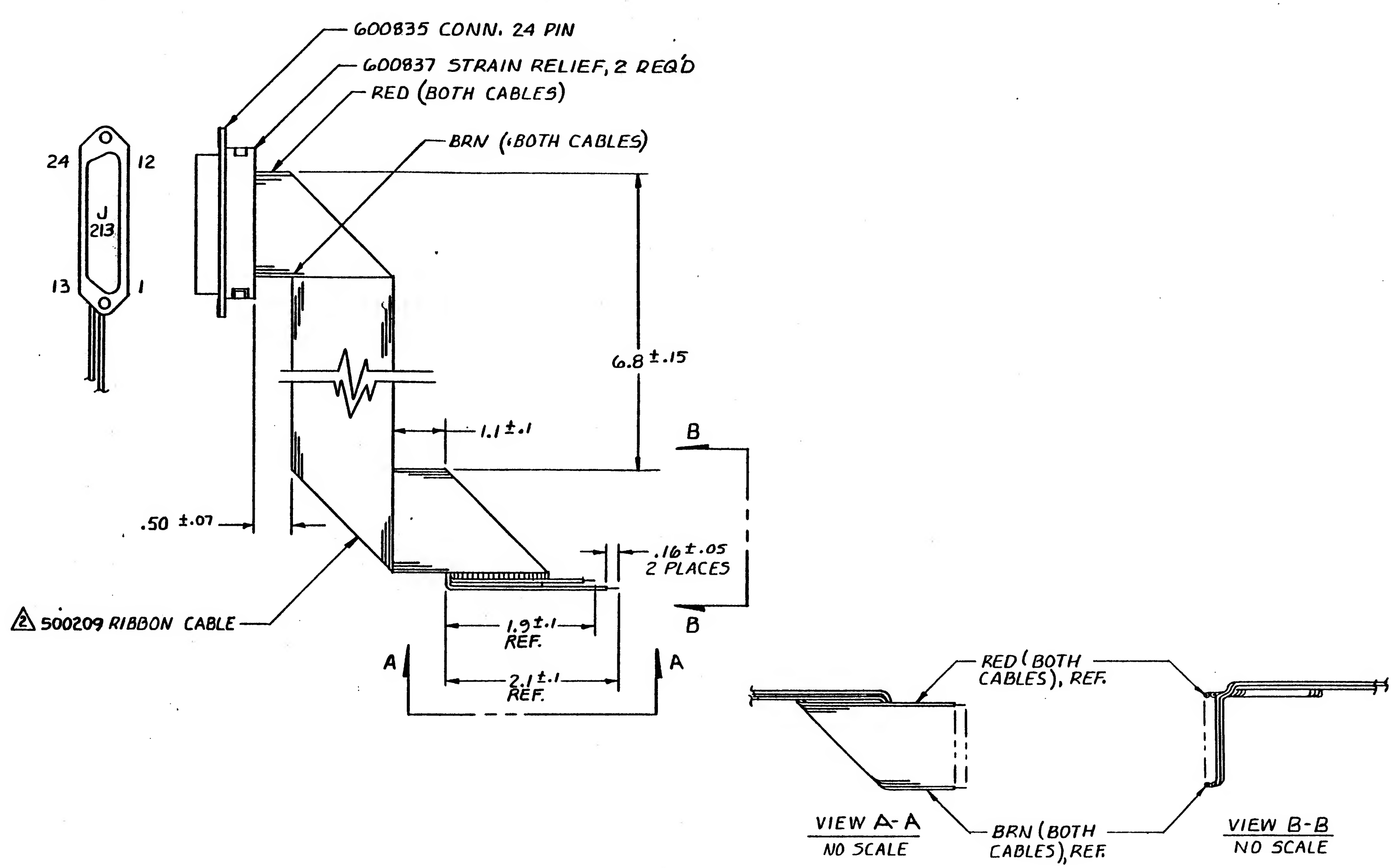
SCALE 2X1 SHEET 1 OF 1



REAR PANEL ADDRESS SWITCHES
ADDRESS COMPARATOR
ASM QUALIFIER MULTIPLEXER
GPIB DATA [DIO] LINE READ BUFFER
µP ADDRESS DECODING
PART OF P2
GPIB STATUS STORAGE
µP DATA BUS BUFFERS
GPIB DATA OUTPUT LATCH
QUALIFIER INVERTER
ASM PROGRAM MEMORY
ASM ADDRESS DECODING
GPIB ADDRESS SWITCH READ BUFFER
QUALIFIER STORAGE AND JUMP LOGIC
ASM ADDRESS REGISTER
GPIB HANDSHAKE LATCH
ASM/µP HANDSHAKE LOGIC
BOARD DETECT
2. CAPACITORS ARE .01µF
1. RESISTOR VALUES ARE IN OHMS, ±5%, 1/4 W
NOTES: UNLESS OTHERWISE SPECIFIED
SCHEMATIC-
GPIB
IEEE-488-1975
SIZE D
CODE IDENT NO. 21793
DWG NO. 431623
REV J
SHEET 1 OF 2



3440 I/O BUFFER
U1
U2
U3
U4
PART OF J213
C10 100V 20%
R2 51Ω
PROPRIETARY NOTICE
D
21793
431623
H
NOTES: UNLESS OTHERWISE SPECIFIED



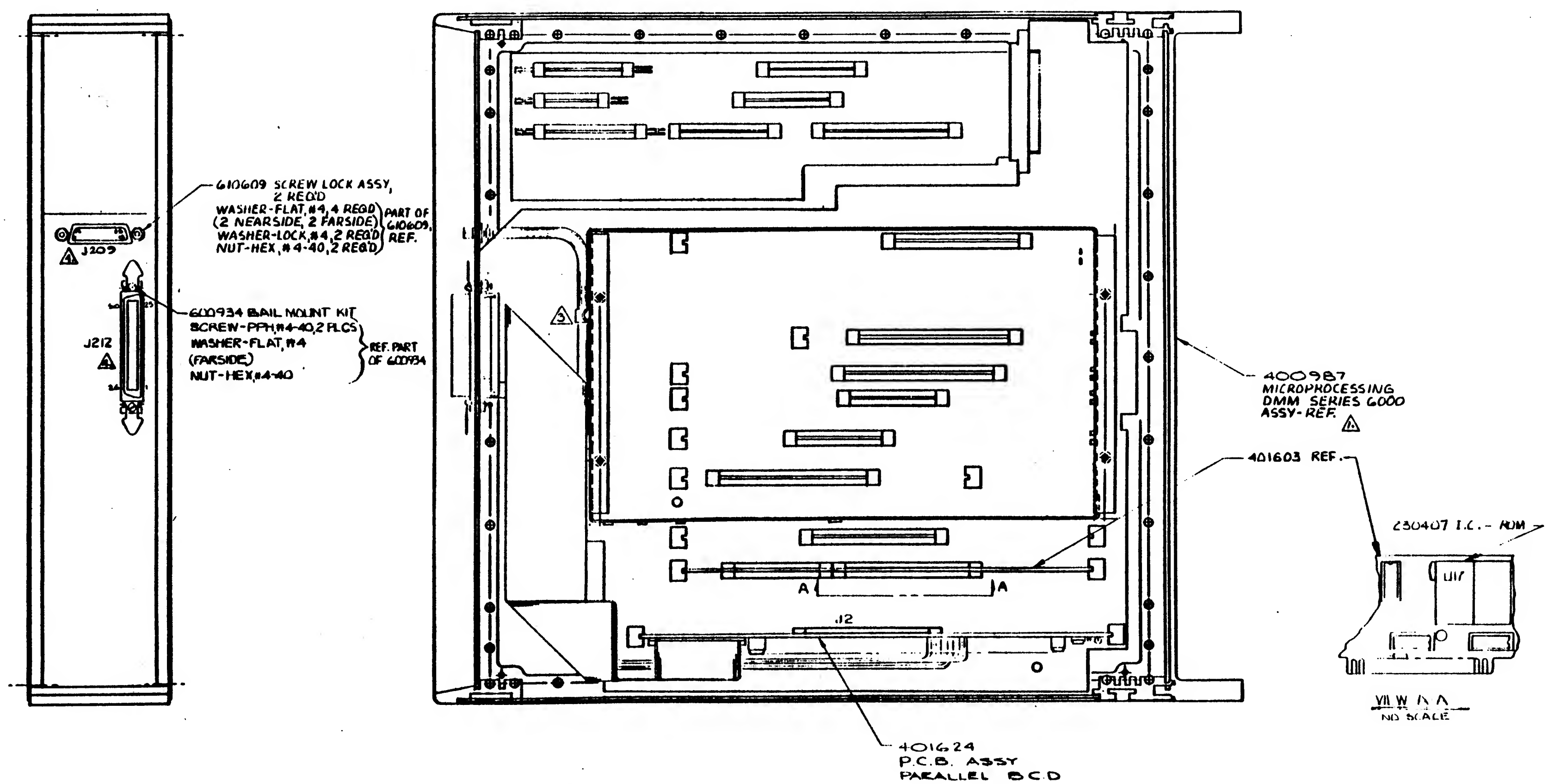
2 CABLE LENGTH PRIOR TO FOLDING WILL BE 13.20 ± .01.

1. ASSY PROCESSES AND PROCEDURES TO CONFORM TO DANA WORKMANSHIP STANDARDS.

NOTES: UNLESS OTHERWISE SPECIFIED

CABLE ASSY - GPIB

SIZE	CODE IDENT NO.	DWG NO.	REV
C	21793	404018	D
SCALE NONE		SHEET 1 OF 2	



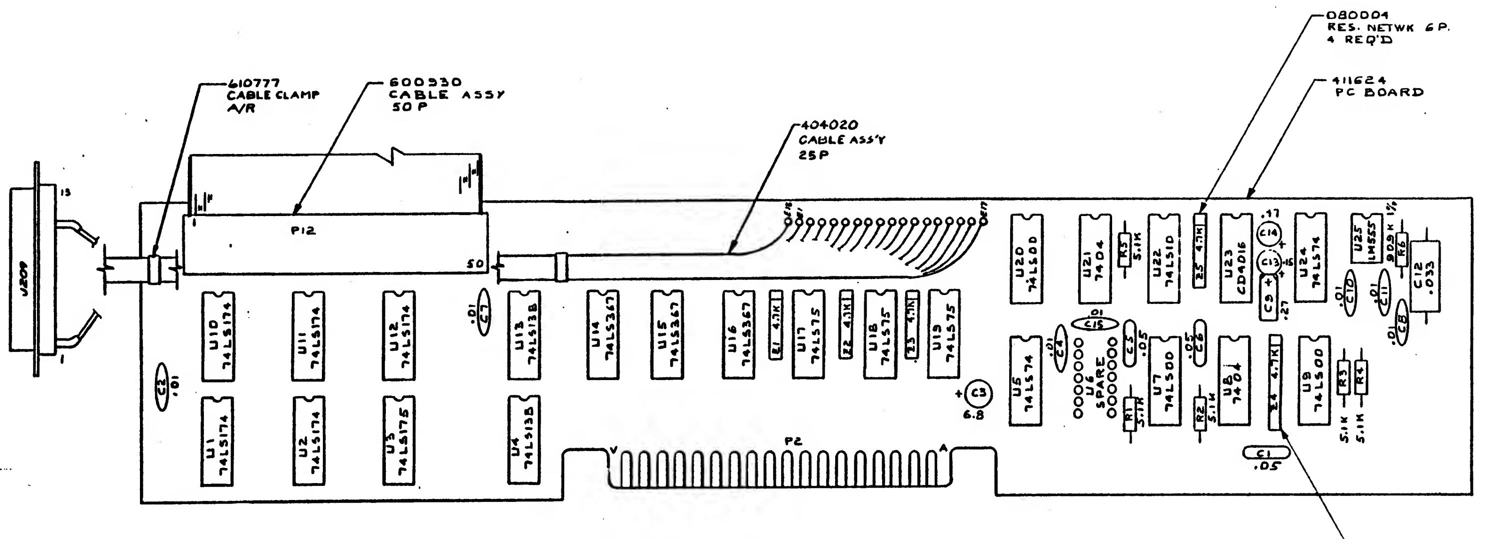
4 REMOVE BUTCH PLATES 454183 & 454184 BEFORE MTG CONNECTORS
3 ROUTE CABLE THRU EXISTING CLAMPS (610491) ON 454177 SHIELD
2 ASSEMBLE PER RACAL-DANA WORKMANSHIP MANUAL
1 COVERS AND OTHER P.C.B ASSY'S NOT SHOWN FOR CLARITY.

NOTES: UNLESS OTHERWISE SPECIFIED

PARALLEL BCD OPTION ASSY

SIZE	CODE IDENT NO	DWG NO.	REV
D	21793	404019	D

SCALE: NONE SHEET 1 OF 2



COMPONENT SIDE SHOWN

'E' NO.	COLOR	J209 PIN NO.
E18	WHT/GRA	22
E17	WHT/VIO	21
E16	WHT/BLU	20
E15	WHT/GRN	19
E14	WHT/YEL	18
E13	WHT/ORN	17
E12	WHT/RED	16
E11	WHT/BRN	15
E10	BLK	14
E9	WHT	9
E8	GRA	8
E7	VIO	7
E6	BLU	6
E5	GRN	5
E4	YEL	4
E3	ORN	3
E2	RED	2
E1	BRN	1

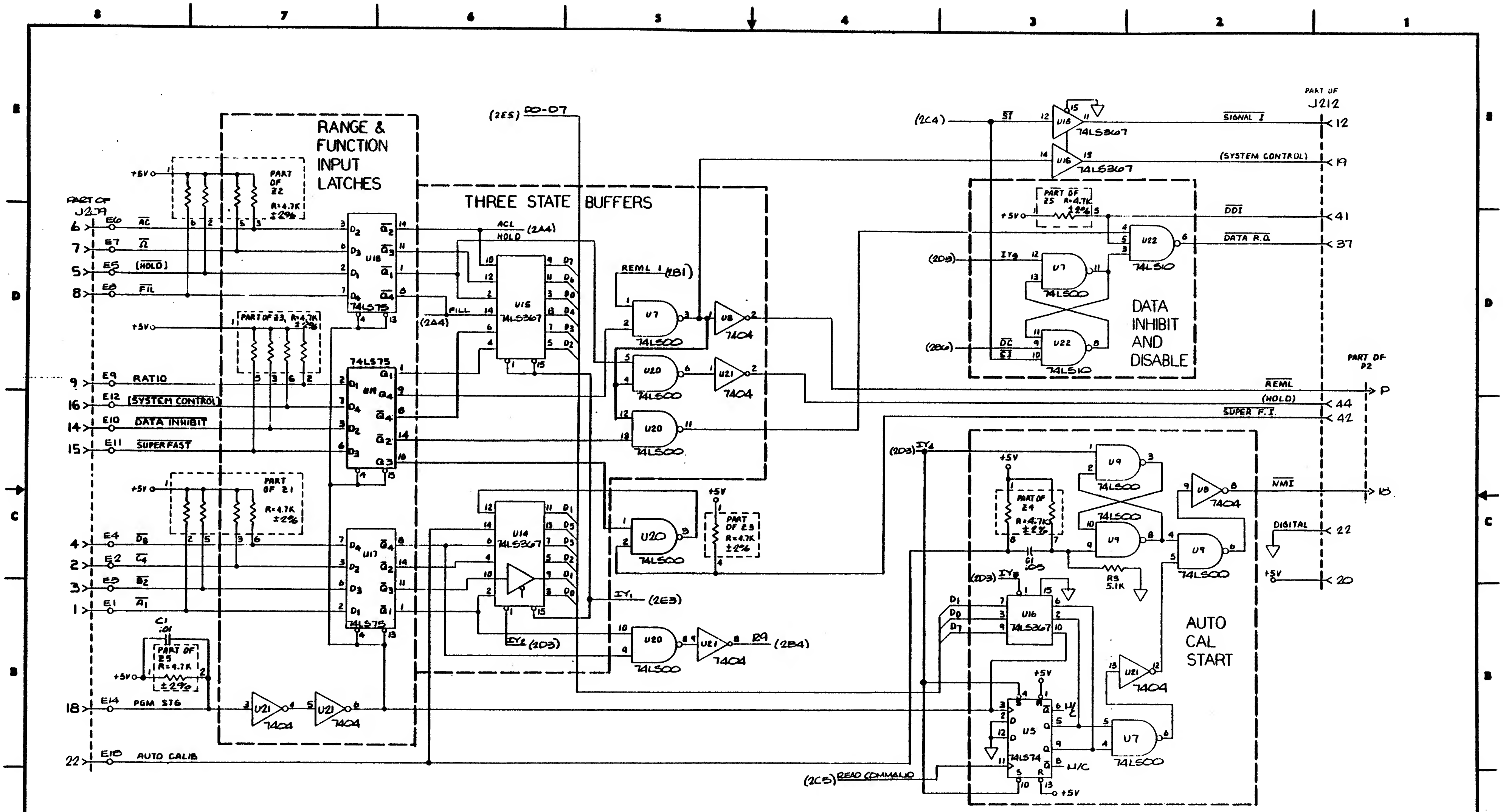
WIRING TABLE

4. ALL CAPACITORS ARE IN MFD
3. RESISTORS ARE ±5% 1/4 W
2. REFERENCE SCHEMATIC NO. 431624
1. ASSEMBLY PROCESSES & PROCEDURES TO CONFORM TO DANA WORKMANSHIP STANDARDS

NOTES: UNLESS OTHERWISE SPECIFIED

P.C. BOARD ASSY
PARALLEL
BCD

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	401624	D
SCALE 2/1		SHEET 1 OF 3	



Z5	
U25	U6
R6	
C14	
E18	
LAST	NOT USED
DESIGNATORS	

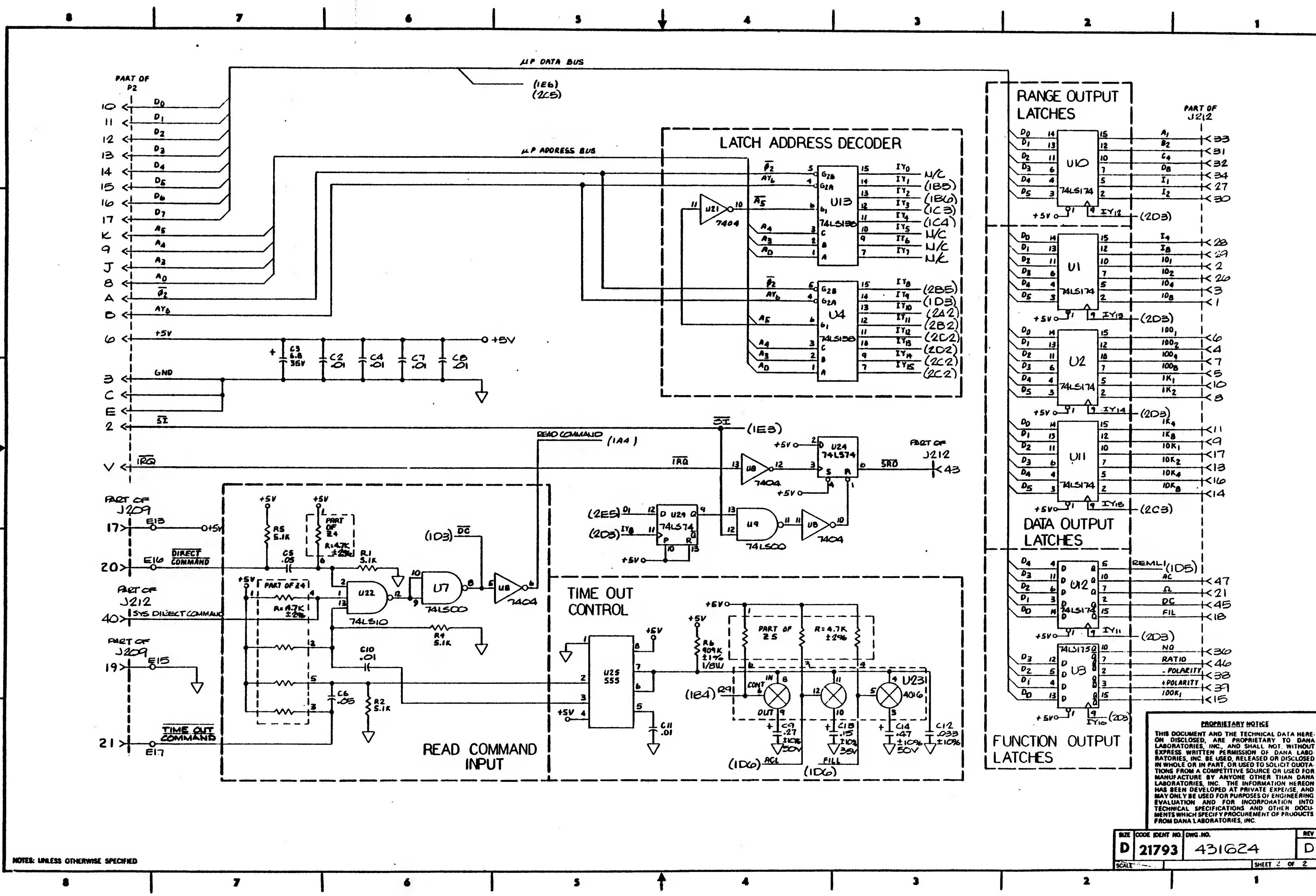
2. ALL CAPACITORS ARE IN MICROFARADS, ±20%, 100 VOLTS.
1. ALL RESISTORS ARE IN OHMS, 1/4 WATT, ±5%.

NOTES: UNLESS OTHERWISE SPECIFIED

SCHEMATIC - PARALLEL BCD

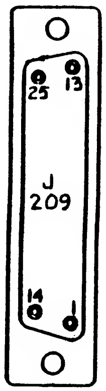
SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	431624	D

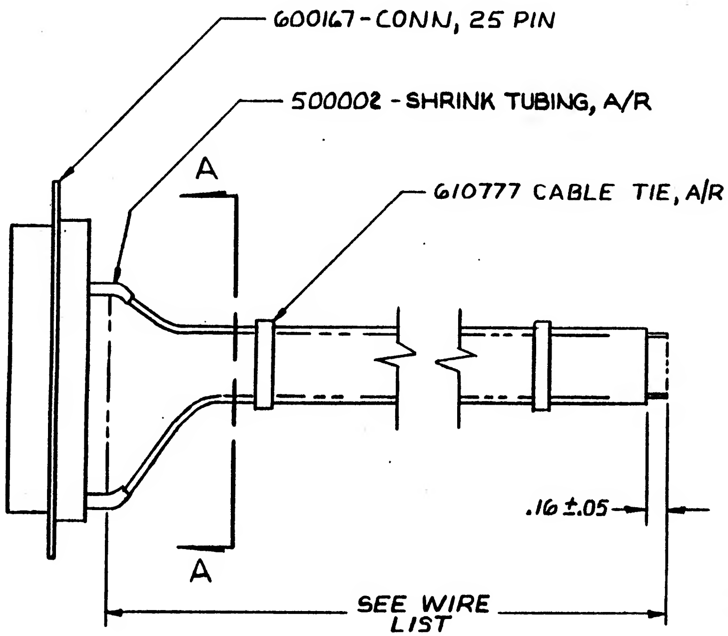
SCALE | SHEET 1 OF 2



SIZE	CODE IDENT NO.	DWG. NO.	REV
D	21793	431624	D

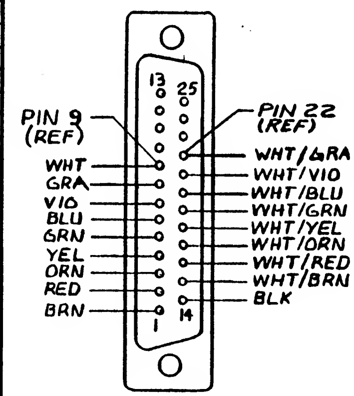
SCALE — SHEET 2 OF 2





J209 PIN #	COLOR	PART NO.	LENGTH ± .15
22	WHT/GRA	524989	20.0
21	WHT/VIO	524979	21.2
20	WHT/BLU	524969	20.0
19	WHT/GRN	524959	20.0
18	WHT/YEL	524949	20.0
17	WHT/ORN	524939	20.0
16	WHT/RED	524929	22.1
15	WHT/BRN	524919	20.0
14	BLK	524000	20.0
9	WHT	524999	20.0
8	GRA	524888	20.0
7	VIO	524777	21.5
6	BLU	524666	21.2
5	GRN	524555	21.2
4	YEL	524444	20.0
3	ORN	524333	20.0
2	RED	524222	20.0
1	BRN	524111	20.0

WIRE LIST

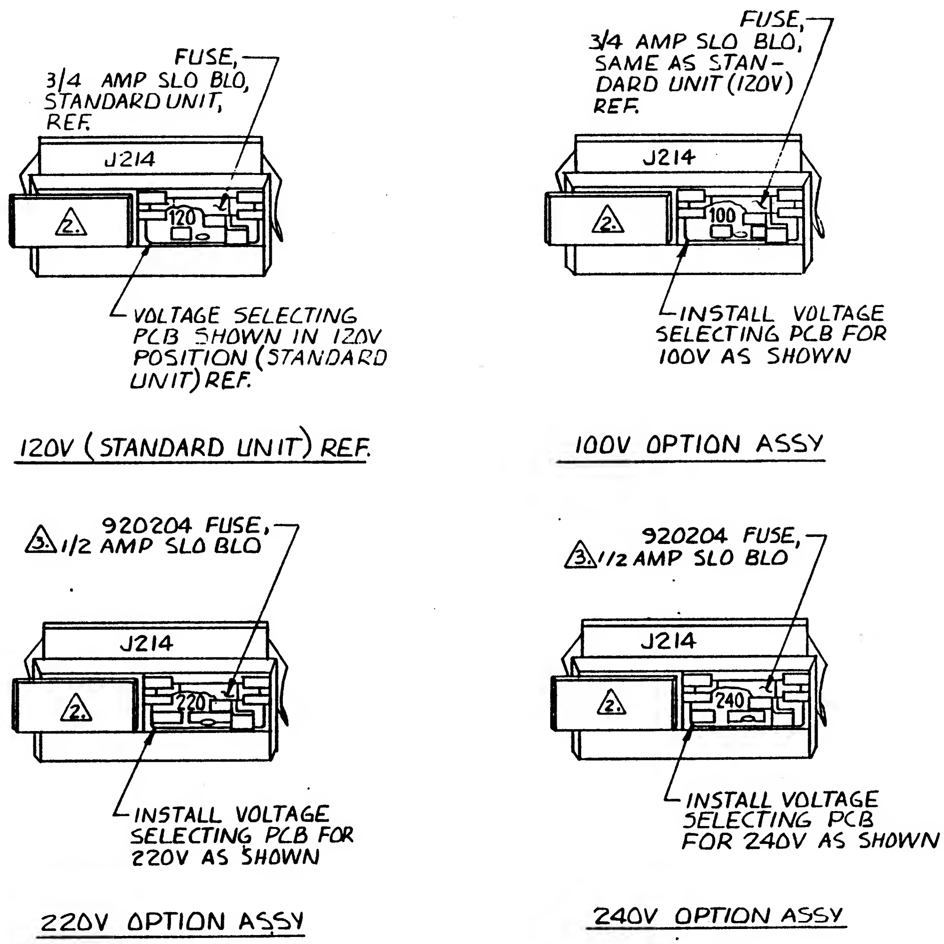


VIEW A-A
SCALE 2/1

NOTES: UNLESS OTHERWISE SPECIFIED
1. ASSY PROCESSES & PROCEDURES TO CONFORM TO DANA WORK. STDS.
2. TAG & IDENTIFY WITH DANA P/N & CURRENT REV. LTR.

CABLE ASSEMBLY- PARALLEL BCD, 25 PIN			
SIZE C	CODE IDENT NO. 21793	DWG NO. 404020	REV C
SCALE 2:1		SHEET OF 3	

7-84



NOTES: UNLESS OTHERWISE SPECIFIED

1. ASSEMBLE PER DANA WORKMANSHIP MANUAL.

2. FUSE & PCB ACCESS COVER SHOWN IN OPEN POSITION.

3. REMOVE & RETURN STANDARD FUSE TO STOCK.

100V, 220V, 240V OPTION ASSY

SIZE	CODE IDENT NO	DWG NO	REV
C	21793	404042	A
SCALE ½		SHEET 1 OF 2	

8.1 This section contains lists of replaceable parts arranged in the order of the following subassemblies:

8.2 Manufacturers are identified by FSC numbers listed in table 8.1, "List of Suppliers". The code numbers are from the Federal Supply Code for Manufacturers Cataloging Handbooks H4-1, H4-2, and their supplements.

Table 8.1 - List of Suppliers

FSC	NAME
00779	AMP, INC. HARRISBURG, PENNSYLVANIA
01121	ALLEN BRADLEY CO. MILWAUKEE, WISCONSIN
01295	TEXAS INSTRUMENTS, INC. DALLAS, TEXAS
02111	SPECTROL ELECTRONICS CORP. CITY OF INDUSTRY, CALIFORNIA
02114	FERROXCUBE CORP. SAUGERTIES, NEW YORK
02660	AMPHENOL CORP. BROADVIEW, ILLINOIS
04222	AEROVOX CORP. (Hi-Q Division) MYRTLE BEACH, SOUTH CAROLINA
04713	MOTOROLA, INC. (Semi Conductor Products Division) PHOENIX, ARIZONA
05397	UNION CARBIDE CORP. (Materials Systems Division) CLEVELAND, OHIO
05574	VIKING INDUSTRIES, INC. CHATSWORTH, CALIFORNIA
06665	PRECISION MONOLITHICS SANTA CLARA, CALIFORNIA
08257	NPC ELECTRONICS CANOGA PARK, CALIFORNIA
09023	CORNELL DUBILIER ELECTRONICS SANFORD, NORTH CAROLINA
11236	CTS OF BERNE, INC. BERNE, INDIANA
11237	CTS KEENE, INC. PASO ROBLES, CALIFORNIA
12406	ELPAC, INC. IRVINE, CALIFORNIA
12969	UNITRODE CORP. WATTERTOWN, MASSACHUSETTS
13919	BURR BROWN TUCSON, ARIZONA
14674	CORNING GLASS WORKS CORNING, NEW YORK

FSC	NAME
14936	GENERAL INSTRUMENTS CORP. (Semiconductor Products Group) HICKSVILLE, L.I., NEW YORK
15636	ELECTROL, INC. SAUGUS, CALIFORNIA
17856	SILICONIX, INC. SANTA CLARA, CALIFORNIA
18324	SIGNETICS CORP. SUNNYVALE, CALIFORNIA
18612	VISHAY RESISTOR PRODUCTS MALVERN, PENNSYLVANIA
19396	ILLINOIS TOOL WORKS, INC. (Paktron Division) ALEXANDRIA, VIRGINIA
21317	ELECTRONIC APPLICATIONS CO. SO. EL MONTE, CALIFORNIA
21551	CF ELECTRONICS, INC. VAN NUYS, CALIFORNIA
21793	RACAL-DANA INSTRUMENTS INC. IRVINE, CALIFORNIA
22045	JORDAN ELECTRIC CO. VAN NUYS, CALIFORNIA
23095	AZTEC ELECTRONICS, INC. ANAHEIM, CALIFORNIA
25088	SIEMENS CORP. (Comp. Group) ISELIN, NEW JERSEY
26806	AMERICAN ZETTLER, INC. COSTA MESA, CALIFORNIA
27014	NATIONAL SEMI CONDUCTOR CORP. SANTA CLARA, CALIFORNIA
27556	IMB ELECTRONIC PRODUCTS, INC. SANTA FE SPRINGS, CALIFORNIA
31471	AMERICAN MICRO SYSTEMS, INC. SANTA CLARA, CALIFORNIA
32767	GRIFFITH PLASTIC PRODUCTS CO. BURLINGAME, CALIFORNIA
34371	HARRIS SEMICONDUCTOR MELBOURNE, FLORIDA

Table 8.1 - List of Suppliers continued

FSC	NAME	FSC	NAME
50434	HEWLETT PACKARD CO. (HPA Division) PALO ALTO, CALIFORNIA	74970	E. F. JOHNSTON CO. WASECA, MINNESOTA
50579	LITRONIX, INC. CUPERTINO, CALIFORNIA	79727	C-W INDUSTRIES WARMINSTER, PENNSYLVANIA
52763	STETTNER-TRUSH CAZENOVIA, NEW YORK	80131	ELECTRONICS INDUSTRIES ASSOC. WASHINGTON, D.C.
56289	SPRAGUE ELECTRIC CO. (Pacific Division) LOS ANGELES, CALIFORNIA	81312	WINCHESTER ELECTRONICS DIVISION (Litton Industries, Inc.) OAKVILLE, CONNECTICUT
71471	AEROVOX CORP. (Cinema Plant) MONCKS CORNER, SOUTH CAROLINA	81349	MILITARY SPECIFICATION
71590	CENTRALAB ELECTRONICS MILWAUKEE, WISCONSIN	86884	RCA (Electronics Components Div.) HARRISON, NEW JERSEY
71785	TRW ELECTRONIC COMPONENTS (Cinch Division) ELK GROVE VILLAGE, ILLINOIS	91293	JOHANSON MFG. CO. BOONTON, NEW JERSEY
72136	ELECTRO MOTIVE MFG. CO., INC. WILLIMANTIC, CONNECTICUT	91637	DALE ELECTRONICS, INC. COLUMBUS, NEBRASKA
72982	ERIE TECHNOLOGICAL PRODUCTS, INC. ERIE, PENNSYLVANIA	95238	CONTINENTAL CONNECTOR WOODSIDE, NEW YORK
73138	BECKMAN INSTRUMENTS, INC. FULLERTON, CALIFORNIA	95275	VITRAMON, INC. BRIDGEPORT, CONNECTICUT
73445	AMPEREX ELECTRONIC CORP. HICKSVILLE, L.I., NEW YORK	98291	SEALECTRO CORP. MAMARONECK, NEW YORK
75915	LITTELFUSE, INC. DES PLAINES, ILLINOIS	99800	AMERICAN PRECISION INDUSTRIES, INC. (Delevan Div.) EAST AURORA, NEW YORK
		—	LIBERTY ELECTRONICS EL SEGUNDO, CALIFORNIA

404011 – Assy., PANEL, FRONT

REF DES	RACAL-DANA P/N	DESCRIPTION	FSC	MANU P/N
S101	601109	SWITCH ROCKER DPST 12(4)A/250V	—	1545-0102
S102	454217	KEYBOARD ASSY	21793	454217

404013, 404169 – REAR PANEL ASSEMBLY

REF DES	RACAL-DANA P/N	DESCRIPTION	FSC	MANU P/N
C201	100111	CAP CERAM .01 MFD 2000 V	71471	HVD6-2KV
C202	100111	CAP CERAM .01 MFD 2000 V	71471	HVD6-2KV
C203	110125	CAP TANTA 2.2 MFD 35 V 20%	05397	T368B225M035AS
C204	110125	CAP TANTA 2.2 MFD 35 V 20%	05397	T368B225M035AS
B201	920790	FAN 50/60 HZ	27556	PWS2107FL
F201	920205	FUSE GLASS .75A 250 V	75915	3AG3/4ASB
J210	600808	CONN BNC	02660	31-010
J211	600586	POST, BINDING WHITE	32767	820-25
J214	600795	CONN VOLTAGE SELECTING & FUSED	95238	6J1
J215	600587	POST, BINDING BLACK	32767	820-45
S201	600912	SWITCH, SLIDE	79727	GF-323-440/G20-30/ G02-150
T201	300091	TRANSFORMER POWER, STEP DOWN	23095	14060
U201	230275	INTEGRATED CIRCUIT MC7805CT	04713	MC7805CT
U202	230275	INTEGRATED CIRCUIT MC7805CT	04713	MC7805CT

401602 – Assy., PCB, MOTHERBOARD

REF DES	RACAL-DANA P/N	DESCRIPTION					FSC	MANU P/N
C1	110151	CAP	TANTA	10 MFD	35 V	20%	05397	T362C106M035AS
C2	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C3	110151	CAP	TANTA	10 MFD	35 V	20%	05397	T362C106M035AS
C4	100113	CAP	CERAM	6800 PFD	1000 V	20%	56289	C012B102H682M
C5	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C6	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C8	110158	CAP	TANTA	10 MFD	50 V	10%	05397	T362C106K050AS
C9	110151	CAP	TANTA	10 MFD	35 V	20%	05397	T362C106M035AS
C10	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C12	110151	CAP	TANTA	10 MFD	35 V	20%	05397	T362C106M035AS
C13	110192	CAP	ELECT	1000 MFD	35 V			35TAL1000
C14	110192	CAP	ELECT	1000 MFD	35 V			35TAL1000
C15	110178	CAP	ELECT	47 MFD	100 V			100VBSL47
C16	110178	CAP	ELECT	47 MFD	100 V			100VBSL47
C17	110178	CAP	ELECT	47 MFD	100 V			100VBSL47
C18	110193	CAP	ELECT	100 MFD	50 V			See Description
C19	110151	CAP	TANTA	10 MFD	35 V	20%	05397	T362C106M035AS
C20	110151	CAP	TANTA	10 MFD	35 V	20%	05397	T362C106M035AS
C21	110194	CAP	ELECT	470 MFD	50 V	Radial Leads		See Description
C23	110151	CAP	TANTA	10 MFD	35 V	20%	05397	T362C106M035AS
C24	110193	CAP	ELEC	100 MFD	50 V			See description
C25	110158	CAP	TANTA	10 MFD	50 V	10%	05397	T362C106K050A
C26	110151	CAP	TANTA	10 MFD	35 V	20%	05397	T362C106M035AS
C27	110151	CAP	TANTA	10 MFD	35 V	20%	05397	T362C106M035AS
C28	110192	CAP	ELECT	1000 MFD	35 V			35TAL1000
C29	110151	CAP	TANTA	10 MFD	35 V	20%	05397	T362C106M035AS
C30	110194	CAP	ELECT	470 MFD	50 V	Radial Leads		See Description
C31	110174	CAP	ELECT	10,000 MFD	15 V			3050HS103U015244G
C32	110151	CAP	TANTA	10 MFD	35 V	20%	05397	T362C106M035AS
C33	110151	CAP	TANTA	10 MFD	35 V	20%	05397	T362C106M035AS
C34	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C35	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
CR1	210004	DIODE	SILICO		1N4004		81349	1N4004
CR2	210004	DIODE	SILICO		1N4004		81349	1N4004
CR3	210004	DIODE	SILICO		1N4004		81349	1N4004
CR4	210004	DIODE	SILICO		1N4004		81349	1N4004
CR5	210004	DIODE	SILICO		1N4004		81349	1N4004
CR6	210004	DIODE	SILICO		1N4004		81349	1N4004
CR7	210004	DIODE	SILICO		1N4004		81349	1N4004
CR8	210004	DIODE	SILICO		1N4004		81349	1N4004
CR9	210004	DIODE	SILICO		1N4004		81349	1N4004
CR10	210070	DIODE	POWER	3 AMP	MR501		04713	MR501

401602 – Assy., PCB, MOTHERBOARD continued

REF DES	RACAL-DANA P/N	DESCRIPTION					FSC	MANU P/N
CR11	210070	DIODE	POWER	3 AMP	MR501		04713	MR501
CR12	210004	DIODE	SILICO		1N4004		81349	1N4004
CR13	210004	DIODE	SILICO		1N4004		81349	1N4004
CR14	210004	DIODE	SILICO		1N4004		81349	1N4004
CR15	210004	DIODE	SILICO		1N4004		81349	1N4004
CR16	220022	DIODE	SILICO, ZENER		1N965B		81349	1N965B
CR17	220035	DIODE	ZENER	16 V	1N966B	5%	81349	1N966B
CR18	210004	DIODE	SILICO		1N4004		81349	1N4004
CR19	210004	DIODE	SILICO		1N4004		81349	1N4004
CR20	210004	DIODE	SILICO		1N4004		81349	1N4004
CR21	210004	DIODE	SILICO		1N4004		81349	1N4004
CR22	210004	DIODE	SILICO		1N4004		81349	1N4004
CR23	210004	DIODE	SILICO		1N4004		81349	1N4004
CR24	210004	DIODE	SILICO		1N4004		81349	1N4004
CR25	210004	DIODE	SILICO		1N4004		81349	1N4004
CR26	210004	DIODE	SILICO		1N4004		81349	1N4004
CR27	210004	DIODE	SILICO		1N4004		81349	1N4004
CR28	210004	DIODE	SILICO		1N4004		81349	1N4004
CR29	210004	DIODE	SILICO		1N4004		81349	1N4004
J300	600733	CONN	25 P	Double Row			05574	3VH25/1JN5
OCI 2	250007	OPTICAL ISOLATOR					50579	1L-74
OCI 3	250006	HI SPEED OPTICAL ISOLATOR					50434	HP5082-4351
OCI 4	250006	HI SPEED OPTICAL ISOLATOR					50434	HP5082-4351
Q1	200183	TRANS	SILICO	PNP	MJE371		04713	MJE371
R2	000301	RES	CARBON	300 OHM		5% 1/4W	81349	RC07GF301J
R3	000102	RES	CARBON	1 K		5% 1/4W	81349	RC07GF102J
R4	000301	RES	CARBON	300 OHM		5% 1/4W	81349	RC07GF301J
R5	000301	RES	CARBON	300 OHM		5% 1/4W	81349	RC07GF301J
R6	000911	RES	CARBON	910 OHM		5% 1/4W	81349	RC07GF911J
R7	001752	RES	CARBON	240 OHM		5% 1W	21793	001752
R8	000104	RES	CARBON	100 K		5% 1/4W	81349	RC07GF104J
T1	300087	TRANS	PULSE				21793	300087
T2	300087	TRANS	PULSE				21793	300087
T3	300087	TRANS	PULSE				21793	300087
U1	230275	IC			MC7805CT		04713	MC7805CT
U2	230408	IC			MM74C165		27014	MM74C165
U4	230404	IC			MC14094BCP		04713	MC14094BCP
U5	230406	IC			MC1412P		04713	MC1412P

401602 – Assy., PCB, MOTHERBOARD continued

REF DES	RACAL-DANA P/N	DESCRIPTION					FSC	MANU P/N
U6	230194	IC			SN74LS74N		01295	SN74LS74N
U7	230403	IC			MM74C14N		27014	MM74C14N
U8	230406	IC			MC1412P		04713	MC1412P
U9	230404	IC			MC14094BCP		04713	MC14094BCP
U10	230330	IC			74LS367		01295	74LS367
U11	230393	IC			MC7824T		04713	MC7824T
U12	230378	IC			7915CT		04713	7915CT
U13	230409	IC			μA7924CT		27014	μA7924CT
U14	230275	IC			MC7805CT		04713	MC7805CT
U15	230373	IC			7815CT		04713	7815CT
W1	600245	JUMPER	INSULATED					L-2007-1LP
Z1	080012	RES	CERMET	15 K	Network	8P,7R 2%	11236	750-81-R15KΩ
Z2	080012	RES	CERMET	15 K	Network	8P,7R 2%	11236	750-81-R15KΩ
Z3	080020	RES	CERMET	10 K	Network	8P,7R 2%	11236	750-81-R10KΩ

404012 – Assy., CABLE, NON-VOLATILE MEMORY

REF DES	RACAL-DANA P/N	DESCRIPTION	FSC	MANU P/N
P11	600566	CONN 6 P	71785	251-06-30-160

401600 – Assy., PCB, DISPLAY

REF DES	RACAL-DANA P/N	DESCRIPTION					FSC	MANU P/N
C1	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C2	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C3	110126	CAP	TANTA	6.8 MFD	35 V	20%	05397	T368B685M035AS
C4	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C5	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C6	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
CR1	210079	LAMP	HI EFFICIENCY, YELLOW		Solid State		50434	HP5082-4555
CR2	210079	LAMP	HI EFFICIENCY, YELLOW		Solid State		50434	HP5082-4555
CR3	210079	LAMP	HI EFFICIENCY, YELLOW		Solid State		50434	HP5082-4555
CR4	210079	LAMP	HI EFFICIENCY, YELLOW		Solid State		50434	HP5082-4555
CR5	210079	LAMP	HI EFFICIENCY, YELLOW		Solid State		50434	HP5082-4555
CR6	210071	LAMP	HI EFFICIENCY, RED		Solid State		50434	HP5082-4650
CR7	210071	LAMP	HI EFFICIENCY, RED		Solid State		50434	HP5082-4650
CR8	210071	LAMP	HI EFFICIENCY, RED		Solid State		50434	HP5082-4650
CR9	210071	LAMP	HI EFFICIENCY, RED		Solid State		50434	HP5082-4650
CR10	210071	LAMP	HI EFFICIENCY, RED		Solid State		50434	HP5082-4650
CR11	210071	LAMP	HI EFFICIENCY, RED		Solid State		50434	HP5082-4650
CR12	210071	LAMP	HI EFFICIENCY, RED		Solid State		50434	HP5082-4650
CR13	210079	LAMP	HI EFFICIENCY, YELLOW		Solid State		50434	HP5082-4555
CR14	210079	LAMP	HI EFFICIENCY, YELLOW		Solid State		50434	HP5082-4555
CR15	210079	LAMP	HI EFFICIENCY, YELLOW		Solid State		50434	HP5082-4555
CR16	210079	LAMP	HI EFFICIENCY, YELLOW		Solid State		50434	HP5082-4555
CR17	210079	LAMP	HI EFFICIENCY, YELLOW		Solid State		50434	HP5082-4555
CR18	210079	LAMP	HI EFFICIENCY, YELLOW		Solid State		50434	HP5082-4555
CR19	210079	LAMP	HI EFFICIENCY, YELLOW		Solid State		50434	HP5082-4555
CR20	210079	LAMP	HI EFFICIENCY, YELLOW		Solid State		50434	HP5082-4555
CR21	210079	LAMP	HI EFFICIENCY, YELLOW		Solid State		50434	HP5082-4555
CR22	210071	LAMP	HI EFFICIENCY, RED		Solid State		50434	HP5082-4650
CR23	210071	LAMP	HI EFFICIENCY, RED		Solid State		50434	HP5082-4650
CR24	210071	LAMP	HI EFFICIENCY, RED		Solid State		50434	HP5082-4650
CR25	210071	LAMP	HI EFFICIENCY, RED		Solid State		50434	HP5082-4650
CR26	210071	LAMP	HI EFFICIENCY, RED		Solid State		50434	HP5082-4650
CR27	210071	LAMP	HI EFFICIENCY, RED		Solid State		50434	HP5082-4650
LED 1	210074	DIODE	7 Segment LED DISPLAY, YELLOW				50434	HP5032-7660
LED 2	210074	DIODE	7 Segment LED DISPLAY, YELLOW				50434	HP5032-7660
LED 3	210074	DIODE	7 Segment LED DISPLAY, YELLOW				50434	HP5032-7660
LED 4	210074	DIODE	7 Segment LED DISPLAY, YELLOW				50434	HP5032-7660
LED 5	210074	DIODE	7 Segment LED DISPLAY, YELLOW				50434	HP5032-7660
LED 6	210074	DIODE	7 Segment LED DISPLAY, YELLOW				50434	HP5032-7660
LED 7	210074	DIODE	7 Segment LED DISPLAY, YELLOW				50434	HP5032-7660
LED 8	210074	DIODE	7 Segment LED DISPLAY, YELLOW				50434	HP5032-7660
LED 9	210074	DIODE	7 Segment LED DISPLAY, YELLOW				50434	HP5032-7660

401600 – Assy., PCB, DISPLAY continued

REF DES	RACAL-DANA P/N	DESCRIPTION					FSC	MANU P/N
P1	600280	CONN		12 P			71785	252-12-30-160
U1	230510	IC			74LS164			74LS164
U2	230510	IC			74LS164			74LS164
U3	230510	IC			74LS164			74LS164
U4	230510	IC			74LS164			74LS164
U5	230510	IC			74LS164			74LS164
U6	230510	IC			74LS164			74LS164
U7	230510	IC			74LS164			74LS164
U8	230510	IC			74LS164			74LS164
U9	230510	IC			74LS164			74LS164
U10	230510	IC			74LS164			74LS164
U11	230330	IC			74LS367		01295	74LS367
U12	230192	IC			SN74LS05N		01295	SN74LS05N
Z1	080026	RES	ARRAY	100 OHMS	13R TO COMMON PIN		27014	RA-13-100N
Z2	080028	RES	ARRAY	150 OHMS	13R TO COMMON PIN		27014	RA-13-150N
Z3	080027	RES	ARRAY	120 OHMS	8R IN DIP		27014	RA-08-120N
Z4	080027	RES	ARRAY	120 OHMS	8R IN DIP		27014	RA-08-120N
Z5	080027	RES	ARRAY	120 OHMS	8R IN DIP		27014	RA-08-120N
Z6	080027	RES	ARRAY	120 OHMS	8R IN DIP		27014	RA-08-120N
Z7	080027	RES	ARRAY	120 OHMS	8R IN DIP		27014	RA-08-120N
Z8	080027	RES	ARRAY	120 OHMS	8R IN DIP		27014	RA-08-120N
Z9	080005	RES	CERMET	10 K	Network	6P.5R 2%	11236	750-61-R10KΩ
Z10	080027	RES	ARRAY	120 OHMS	8R IN DIP		27014	RA-08-120N

404015 – MODULE ASSY., CALIBRATION

REF DES	RACAL-DANA P/N	DESCRIPTION		FSC	MANU P/N
J101	600587	POST, BINDING	BLACK	32767	820-45
J102	600586	POST, BINDING	WHITE	32767	820-25
J103	600587	POST, BINDING	BLACK	32767	820-45
J104	600586	POST, BINDING	WHITE	32767	820-25
J105	600587	POST, BINDING	BLACK	32767	820-45
J201	600586	POST, BINDING	WHITE	32767	820-25
J202	600587	POST, BINDING	BLACK	32767	820-45
J203	600587	POST, BINDING	BLACK	32767	820-45
J204	600586	POST, BINDING	WHITE	32767	820-25
J205	600587	POST, BINDING	BLACK	32767	820-45
J206	600586	POST, BINDING	WHITE	32767	820-25
J207	600587	POST, BINDING	BLACK	32767	820-45
P308	600944	CONN	3S1P	81312	JF1P-3SB
S126	600910	SWITCH, MINIATURE		79727	GF-126-DP-DT
S127	600910	SWITCH, MINIATURE		79727	GF-126-DP-DT

401608 – Assy., PCB, ATTENUATOR REFERENCE

REF DES	RACAL-DANA P/N	DESCRIPTION					FSC	MANU P/N
AR1	230191	IC			(OP-07CJ)		06665	TO-99(J)MONO
AR2	230103	IC			LM308		27014	LM308
C1	110126	CAP	TANTA	6.8 MFD	35 V	20%	05397	T368B685M035AS
C2	110126	CAP	TANTA	6.8 MFD	35 V	20%	05397	T368B685M035AS
C3	100113	CAP	CERAM	6800 PFD	1000 V	20%	56289	C023B102H682M
C4	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C5	120308	CAP	POLY	.047 MFD	250 V	10%	73445	C280MAE/A47K
C6	110126	CAP	TANTA	6.8 MFD	35 V	20%	05397	T368B685M035AS
C7	100068	CAP	CERAM	.02 MFD	100 V	20%	56289	C023B101H203M
C10	120290	CAP	MYLAR	.22 MFD	100 V	20%	73455	C281AH/A220K
C11	110126	CAP	TANTA	6.8 MFD	35 V	20%	05397	T368B685M035AS
C12	110126	CAP	TANTA	6.8 MFD	35 V	20%	05397	T368B685M035AS
C13	110126	CAP	TANTA	6.8 MFD	35 V	20%	05397	T368B685M035AS
C14	100012	CAP	CERAM	33 PFD	500 V	10%	71471	TCD-DI-1(N750)
C15	120290	CAP	MYLAR	.22 MFD	100 V	20%	73445	C281AH/A220K
CR3	220004	DIODE	SILICO, ZENER		1N961B		81349	1N961B
CR4	220004	DIODE	SILICO, ZENER		1N961B		81349	1N961B
CR5	220085	DIODE	ZENER		TVS515		12969	TVS515
CR6	220085	DIODE	ZENER		TVS515		12969	TVS515
E9	600766	EYELET	TEFLON				98291	X-121973-1
E10	600766	EYELET	TEFLON				98291	X-121973-1
E11	600766	EYELET	TEFLON				98291	X-121973-1
E12	600766	EYELET	TEFLON				98291	X-121973-1
E13	600766	EYELET	TEFLON				98291	X-121973-1
E14	600766	EYELET	TEFLON				98291	X-121973-1
E15	600766	EYELET	TEFLON				98291	X-121973-1
E16	600766	EYELET	TEFLON				98291	X-121973-1
E17	600766	EYELET	TEFLON				98291	X-121973-1
E18	600766	EYELET	TEFLON				98291	X-121973-1
J308	600943	CONN		3P1S			81312	JF1S-3PB
K1	310112	RELAY	REED	28 V			26806	AZ421-467-204
K2	310112	RELAY	REED	28 V			26806	AZ421-467-204
K3	310112	RELAY	REED	28 V			26806	AZ421-467-204
K4	310112	RELAY	REED	28 V			26806	AZ421-467-204
K5	310111	RELAY	REED	28 V			26806	AZ420-467-202
K6	310111	RELAY	REED	28 V			26806	AZ420-467-202
K7	310111	RELAY	REED	28 V			26806	AZ420-467-202

REF DES	RACAL-DANA P/N	DESCRIPTION					FSC	MANU P/N
Q1	200088	DIODE	SILICO	PNP	2N4248		80131	2N4248
Q2	200200	DIODE		NPN	200200		21793	200200
Q3	200200	DIODE		NPN	200200		21793	200200
Q4	200200	DIODE		NPN	200200		21793	200200
Q5	200200	DIODE		NPN	200200		21793	200200
Q6	200200	DIODE		NPN	200200		21793	200200
R1	020640	RES	WW	ATTENUATOR SET			21793	020640
R2	020640	RES	WW	ATTENUATOR SET			21793	020640
R3	020640	RES	WW	ATTENUATOR SET			21793	020640
R4	020640	RES	WW	ATTENUATOR SET			21793	020640
R5	020640	RES	WW	ATTENUATOR SET			21793	020640
R6	010871	RES		5 K	Matched Set		21793	010871
R7	000133	RES	CARBON	13 K		5% 1/4W	81349	RC07GF133J
R8	000100	RES	CARBON	10 OHM		5% 1/4W	81349	RC07GF100J
R9	010646	RES	METAL	2.49 K		1% 1/10W	81349	RN55C2491F
R10	010871	RES		5 K	Matched Set		21793	010871
R11	000162	RES	CARBON	1.6 K		5% 1/4W	81349	RC07GF162J
R12	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R15	010770	RES	METAL	45.0097 K		.01%	18612	HP202
R16	010769	RES	METAL	4.5 K		.01%	18612	HP202
R17	012037	RES	METAL	69 OHM		.1%	18612	HP202
R18	010790	RES	METAL	36.5 K		1% 1/10W	81349	RN55E3652F
R19	000206	RES	CARBON	20 M		5% 1/4W	81349	RC07GF206J
R20	000102	RES	CARBON	1 K		5% 1/4W	81349	RC07GF102J
R21	010529	RES	METAL	10 K		1% 1/10W	81349	RN55C1002F
R22	020716	RES	WW	10 K		.1% .05W	22045	J90
R23	000202	RES	CARBON	2 K		5% 1/4W	81349	RC07GF202J
R24	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R25	000390	RES	CARBON	39 OHM		5% 1/4W	81349	RC07GF390J
R26	010616	RES	METAL	50 K		.1% 1/10W	81349	RN55C5002B
R27	012051	RES	METAL	431 OHM		.1%	18612	HP202
R28	020640	RES	WW	ATTENUATOR SET			21793	020640
R29	030015	RES	WW	100 K		1% 10W	21551	M100
R30	040235	POT	CERMET	100 K		10% 3/4W	73138	89PR100K
R31	010790	RES	METAL	36.5 K		1% 1/10W	81349	RN55E3652F
R32	040235	POT	CERMET	100 K		10% 3/4W	73138	89PR100K
R33	000102	RES	CARBON	1 K		5% 1/4W	81349	RC07GF102J
R34	000100	RES	CARBON	10 OHM		5% 1/4W	81349	RC07GF100J
R36	000102	RES	CARBON	1 K		5% 1/4W	81349	RC07GF102J
R37	000101	RES	CARBON	100 OHM		5% 1/4W	81349	RC07GF101J
R38	000101	RES	CARBON	100 OHM		5% 1/4W	81349	RC07GF101J
SG1	920821	SPARK GAP					25088	B1-A230
TP1	600786	POST, MACHINE APPLIED STRIP					00779	1-87022-0
TP2	600786	POST, MACHINE APPLIED STRIP					00779	1-87022-0

401608 – Assy., PCB, ATTENUATOR REFERENCE continued

REF DES	RACAL-DANA P/N	DESCRIPTION		FSC	MANU P/N
TP3	600786	POST, MACHINE APPLIED STRIP		00779	1-87022-0
TP4	600786	POST, MACHINE APPLIED STRIP		00779	1-87022-0
TP5	600786	POST, MACHINE APPLIED STRIP		00779	1-87022-0
U1	230406	IC	MC1412P	04713	MC1412P
U2	230612	IC DIGITAL	CD4094	02735	CD4094

403916 – Assy., PCB, 10V REFERENCE

REF DES	RACAL-DANA P/N	DESCRIPTION	FSC	MANU P/N
AR1	230127	INTEGRATED CIRCUIT SSS725C	06665	SSS725C
CR1	403686	RESISTOR SET ASSEMBLY	21793	403686
Q1	200196	TRANS NPN 2N3568	81349	2N3568
Q2	200200	TRANS NPN 200200	21793	200200
R1	403686	RESISTOR SET ASSEMBLY	21793	403686
R2	020641	RES WW 10 K 1% .05W	22045	J90
R3	040232	POT CERMET 10 K 10%	73138	89PR10K
R4	040235	POT CERMET 100 K 10% 3/4W	73138	89PR100K
R5	040236	POT CERMET 200 K 10%	73138	89PR200K
R6	000565	RES CARBON 5.6 M 5% 1/4W	81349	RC07GF565J
R7	010774	RES METAL 3.7 K .1%	18612	V53-1
R8	010773	RES METAL 6.3 K .1%	18612	V53-1
R9	403686	RESISTOR SET ASSEMBLY	21793	403686
R10	403686	RESISTOR SET ASSEMBLY	21793	403686
R11	010879	RES METAL 1 M 1% 1/10W	81349	RN55D1004F
R12	012007	RES METAL 23.2 K (Nom) FSV 1% (RN55C)	21793	012007

401611 – Assy., PCB, INTERCONNECTION

REF DES	RACAL-DANA P/N	DESCRIPTION	FSC	MANU P/N
C1	100017	CAP CERAM .01 MFD 100 V 20%	56289	C023B101F103M
C2	100017	CAP CERAM .01 MFD 100 V 20%	56289	C023B101F103M
C3	100017	CAP CERAM .01 MFD 100 V 20%	56289	C023B101F103M
C4	100022	CAP CERAM 2000 PFD 1000 V 10%	56289	10SS-D20
C5	100113	CAP CERAM 6800 PFD 1000 V 20%	56289	C023B102H682M
C6	100017	CAP CERAM .01 MFD 100 V 20%	56289	C023B101F103M
J301	600228	CONN 18 P	71785	252-18-30-160
J302	600280	CONN 12 P	71785	252-12-30-160
J303	600280	CONN 12 P	71785	252-12-30-160
J304	600280	CONN 12 P	71785	252-12-30-160
J305	600671	CONN 6 P	71785	252-06-30-160
J306	600280	CONN 12 P	71785	252-12-30-160
J307	600670	CONN 10 P	71785	252-10-30-160
Q1	200088	TRANS SILICO PNP 2N4248	80131	2N4248
Q2	200200	TRANS NPN 200200	21793	200200
R1	000104	RES CARBON 100 K 5% 1/4W	81349	RC07GF104J
R2	000683	RES CARBON 68 K 5% 1/4W	81349	RC07GF683J
R3	000204	RES CARBON 200 K 5% 1/4W	81349	RC07GF204J
R4	000102	RES CARBON 1 K 5% 1/4W	81349	RC07GF102J
R5	000203	RES CARBON 20 K 5% 1/4W	81349	RC07GF203J
R6	000473	RES CARBON 47 K 5% 1/4W	81349	RC07GF473J
R7	000472	RES CARBON 4.7 K 5% 1/4W	81349	RC07GF472J
R8	000153	RES CARBON 15 K 5% 1/4W	81349	RC07GF153J
R9	000223	RES CARBON 22 K 5% 1/4W	81349	RC07GF223J
U1	230408	IC MM74C165	27014	MM74C165
U2	230405	IC MC14528BCP	04713	MC14528BCP
U3	230612	IC DIGITAL CD4094 4BCP	02735	CD4094 4BCP
U4	230406	IC MC1412P	04713	MC1412P
Z1	080030	RES CERMET 22 K Network 8P,7R 2%	11236	750-81-R22KΩ

401613 – Assy., PCB, NON-VOLATILE MEMORY

REF DES	RACAL-DANA P/N	DESCRIPTION					FSC	MANU P/N
C1	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C2	110126	CAP	TANTA	6.8 MFD	35 V	20%	05397	T368B685M035AS
C3	100071	CAP	CERAM	.001 MFD	1000 V	20%	56289	C023B102E102M
C4	110126	CAP	TANTA	6.8 MFD	35 V	20%	05397	T368B685M035AS
C5	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C6	110126	CAP	TANTA	6.8 MFD	35 V	20%	05396	T368B685M035AS
C7	120001	CAP	MYLAR	.0033 MFD	100 V	10%	09023	WMF1D33
C8	100017	CAP	CERAM	.01 MFD	1000 V	20%	56289	C023B101F103M
CR1	211083	DIODE	SILICO		1N916B		81349	1N916B
CR2	211083	DIODE	SILICO		1N916B		81349	1N916B
CR3	211083	DIODE	SILICO		1N916B		81349	1N916B
CR4	211083	DIODE	SILICO		1N916B		81349	1N916B
Q1	200088	TRANS	SILICO	PNP	2N4258		80131	2N4258
Q2	200088	TRANS	SILICO	PNP	2N4258		80131	2N4258
Q3	200088	TRANS	SILICO	PNP	2N4258		80131	2N4258
Q4	200088	TRANS	SILICO	PNP	2N4258		80131	2N4258
Q5	200200	TRANS		NPN	200200		21793	200200
Q6	200101	TRANS		FET	2N5245		81349	2N5245
Q7	200088	TRANS	SILICO	PNP	2N4248		80131	2N4248
Q8	200088	TRANS	SILICO	PNP	2N4248		80131	2N4248
R1	000182	RES	CARBON	1.8 K		5% 1/4W	81349	RC07GF182J
R2	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R3	000204	RES	CARBON	200 K		5% 1/4W	81349	RC07GF204J
R4	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R5	000204	RES	CARBON	200 K		5% 1/4W	81349	RC07GF204J
R6	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R7	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R8	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R9	000913	RES	CARBON	91 K		5% 1/4W	81349	RC07GF913J
R10	000182	RES	CARBON	1.8 K		5% 1/4W	81349	RC07GF182J
R11	000163	RES	CARBON	16 K		5% 1/4W	81349	RC07GF163J
R12	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
U1	230356	IC			74LS175		27014	74LS175
U2	230196	IC			SN74LS51N		01295	SN74LS51N
U3	230193	IC			SN74LS00N		01295	SN74LS00N
U4	230558	IC	MEMORY	2048X8	PROM		21793	230558
U5	230330	IC			74LS367		01295	74LS367

401613 – Assy., PCB, NON-VOLATILE MEMORY continued

REF DES	RACAL-DANA P/N	DESCRIPTION					FSC	MANU P/N
U6	230363	IC			LM555CN		27014	LM555CN
Z1	080009	RES	CERMET	6.8 K	Network	16P,8R 2%	11236	761-3-R6.8KΩ
Z2	080004	RES	CERMET	4.7 K	Network	6P,5R 2%	11236	750-61-R4.7KΩ
Z3	080014	RES	CERMET	15 K	Network	6P,5R 2%	11236	750-61-R15KΩ
Z4	080023	RES	CERMET	4.7 K	Network	8P,7R	11236	750-81-R4.7KΩ

401609 – Assy., PCB, DIGITIZER

REF DES	RACAL-DANA P/N	DESCRIPTION	FSC	MANU P/N
AR1	230415	IC HI VOLTAGE OP AMP LM343H	27014	LM343H
C1	101644	CAP CERAM 200 PFD 1000 V 20%	71471	GPDX5F201K
C2	101642	CAP CERAM 150 PFD 500 V 10%	71471	SCD1X5F
C3	120326	CAP MYLAR 1.0 MFD 50 V 5%	12406	PD5B105J
C4	120343	CAP MYLAR 1 MFD 50 V 10%	27556	Z5R105K
C5	110127	CAP TANTA 22 MFD 6 V 20%	05397	T368B226M006AS
C6	100017	CAP CERAM .01 MFD 100 V 20%	56289	C023B101F103M
C7	110127	CAP TANTA 22 MFD 6 V 20%	05397	T368B226M006AS
C8	101644	CAP CERAM 200 PFD 1000 V 20%	71471	GPDX5F201K
C9	110126	CAP TANTA 6.8 MFD 35 V 20%	05397	T368B685M035AS
C10	110125	CAP TANTA 2.2 MFD 35 V 20%	05397	T368B225M035AS
C11	100068	CAP CERAM .02 MFD 100 V 20%	56289	C023B101H203M
C12	110139	CAP TANTA .22 MFD 35 V 20%	05397	T368A224M035AS
C13	101642	CAP CERAM 150 PFD 500 V 10%	71471	SCD1X5F
C14	101642	CAP CERAM 150 PFD 500 V 10%	71471	SCD1X5F
C15	100017	CAP CERAM .01 MFD 100 V 20%	56289	C023B101F103M
C16	101641	CAP CERAM 470 PFD 500 V 10%	71471	SCD1X5F
C17	101098	CAP CERAM 330 PFD 500 V 10%	56289	10TS-T33
C18	101174	CAP CERAM .001 MFD 500 V 10%	04222	SCD-DI-2X5F-1000
C19	100017	CAP CERAM .01 MFD 100 V 20%	56289	C023B101F103M
C20	110126	CAP TANTA 6.8 MFD 35 V 20%	05397	T368B685M035AS
C21	110158	CAP TANTA 10 MFD 50 V 10%	05397	T362C106K050A
C22	101644	CAP CERAM 200 PFD 1000 V 20%	71471	GPDX5F201K
C23	100018	CAP CERAM 120 PFD 500 V 10%	71471	ETCD(N5600)
C24	100100	CAP CERAM FSV	21793	100100
C25	101175	CAP POLY 220 PFD 500 V 10%	71471	SCD1X5F
C26	100017	CAP CERAM .01 MFD 100 V 20%	56289	C023B101F103M
C29	101642	CAP CERAM 150 PFD 500 V 10%	71471	SCD1X5F
C30	120343	CAP MYLAR 1 MFD 50 V 10%	27556	Z5R105K
C32	100017	CAP CERAM .01 MFD 100 V 20%	56289	C023B101F103M
CR2	211083	DIODE SILICO 1N916B	81349	1N916B
CR3	211083	DIODE SILICO 1N916B	81349	1N916B
CR4	211083	DIODE SILICO 1N916B	81349	1N916B
CR5	211083	DIODE SILICO 1N916B	81349	1N916B

401609 – Assy., PCB, DIGITIZER continued

REF DES	RACAL-DANA P/N	DESCRIPTION					FSC	MANU P/N
CR6	211083	DIODE	SILICO		1N916B		81349	1N916B
CR7	211083	DIODE	SILICO		1N916B		81349	1N916B
CR8	211083	DIODE	SILICO		1N916B		81349	1N916B
CR9	211083	DIODE	SILICO		1N916B		81349	1N916B
CR10	211083	DIODE	SILICO		1N916B		81349	1N916B
CR11	211083	DIODE	SILICO		1N916B		81349	1N916B
CR12	211083	DIODE	SILICO		1N916B		81349	1N916B
CR13	211083	DIODE	SILICO		1N916B		81349	1N916B
CR14	211083	DIODE	SILICO		1N916B		81349	1N916B
CR15	220059	DIODE	ZENER	33 V	1N973B	5%	81349	1N973B
CR16	220054	DIODE	ZENER		1N5260B		81349	1N5260B
CR17	220031	DIODE	SILICO, ZENER	3.3 V	1/4M3.3AZ5		04713	1/4M3.3AZ5
CR18	220031	DIODE	SILICO, ZENER	3.3 V	1/4M3.3AZ5		04713	1/4M3.3AZ5
CR19	211083	DIODE	SILICO		1N916B		81349	1N916B
CR20	211083	DIODE	SILICO		1N916B		81349	1N916B
CR21	211083	DIODE	SILICO		1N916B		81349	1N916B
CR22	211083	DIODE	SILICO		1N916B		81349	1N916B
K1	310139	RELAY	MAGNETIC REED		1 Form A		21317	RR10-1259
Q1	200037	TRANS	SILICO	NPN	2N3646		80131	2N3646
Q2	200037	TRANS	SILICO	NPN	2N3646		80131	2N3646
Q3	200037	TRANS	SILICO	NPN	2N3646		80131	2N3646
Q4	200037	TRANS	SILICO	NPN	2N3646		80131	2N3646
Q7	200160	TRANS		FET	E-304		17856	E-304
Q8	200161	TRANS		Dual FET	E-415		17856	E-415
Q9	200068	TRANS		PNP	2N4250		80131	2N4250
Q10	200203	TRANS		FET	E-201		17856	E-201
Q11	200160	TRANS		FET	E-304		17856	E-304
Q12	200037	TRANS	SILICO	NPN	2N3646		80131	2N3646
Q13	200099	TRANS		PNP	2N4258		81349	2N4258
Q14	200037	TRANS	SILICO	NPN	2N3646		80131	2N3646
Q15	200201	TRANS		Dual NPN	200201		21793	200201
Q16	200160	TRANS		FET	E-304		17856	E-304
Q17	200200	TRANS		NPN	200200		21793	200200
Q18	200203	TRANS		FET	E-201		17856	E-201
Q19	200088	TRANS	SILICO	PNP	2N4248		80131	2N4248
Q20	200088	TRANS	SILICO	PNP	2N4248		80131	2N4248

REF DES	RACAL-DANA P/N	DESCRIPTION					FSC	MANU P/N
Q21	200162	TRANS		FET	KE4391		21793	200162
Q22	200162	TRANS		FET	KE4391		21793	200162
Q23	200179	TRANS		FET	KE4391		27014	KE4391
Q24	200088	TRANS	SILICO	PNP	2N4248		80131	2N4248
Q25	200224	TRANS		NPN	(Selected 200200)		21793	200224
Q26	200088	TRANS	SILICO	PNP	2N4248		80131	2N4248
Q27	200224	TRANS		NPN	(Selected 200200)		21793	200224
Q28	200245	TRANS		PNP	MPS-A92		04713	MPS-A92
Q29	200088	TRANS	SILICO	PNP	2N4248		80131	2N4248
Q30	200200	TRANS		NPN	200200		21793	200200
Q31	200224	TRANS		NPN	(Selected 200200)		21793	200224
Q32	200088	TRANS	SILICO	PNP	2N4248		80131	2N4248
Q33	200088	TRANS	SILICO	PNP	2N4248		80131	2N4248
Q34	200200	TRANS		NPN	200200		21793	200200
Q35	200088	TRANS	SILICO	PNP	2N4248		80131	2N4248
Q36	200200	TRANS		NPN	200200		21793	200200
Q37	200088	TRANS	SILICO	PNP	2N4248		80131	2N4248
Q38	200200	TRANS		NPN	200200		21793	200200
R1	000153	RES	CARBON	15 K		5% 1/4W	81349	RC07GF153J
R2	000272	RES	CARBON	2.7 K		5% 1/4W	81349	RC07GF272J
R3	000152	RES	CARBON	1.5 K		5% 1/4W	81349	RC07GF152J
R4	000153	RES	CARBON	15 K		5% 1/4W	81349	RC07GF153J
R5	000511	RES	CARBON	510 OHM		5% 1/4W	81349	RC07GF511J
R6	000511	RES	CARBON	510 OHM		5% 1/4W	81349	RC07GF511J
R7	000511	RES	CARBON	510 OHM		5% 1/4W	81349	RC07GF511J
R8	000272	RES	CARBON	2.7 K		5% 1/4W	81349	RC07GF272J
R10	010013	RES	METAL	60.4 K	T-2	1% 1/8W	81349	RN60C6042F
R12	010868	RES	METAL	14.3 K		1% 1/10W	81349	RN55D1432F
R13	010169	RES	METAL	100 K	T-0	1% 1/8W	81349	RN60D1003F
R14	010059	RES	METAL	20 K	T-0	1% 1/8W	81349	RN60D2002F
R15	010502	RES	METAL	249 K		1% 1/8W	81349	RN60D2493F
R16	010536	RES	METAL	100 K		1% 1/10W	81349	RN55C1003F
R17	010918	RES	METAL	499 OHM		1% 1/10W	81349	RN55C4990F
R18	000473	RES	CARBON	47 K		5% 1/4W	81349	RC07GF473J
R19	010013	RES	METAL	60.4 K	T-2	1% 1/8W	81349	RN60C6042F
R20	000180	RES	CARBON	18 OHM		5% 1/4W	81349	RC07GF180J
R21	000511	RES	CARBON	18 OHM		5% 1/4W	81349	RC07GF180J
R22	000393	RES	CARBON	39 K		5% 1/4W	81349	RC07GF393J

REF DES	RACAL-DANA P/N	DESCRIPTION				FSC	MANU P/N
R23	010621	RES	METAL	49.9 K	1% 1/10W	81349	RN55C4992F
R24	010621	RES	METAL	49.9 K	1% 1/10W	81349	RN55C4992F
R25	000104	RES	CARBON	100 K	5% 1/4W	81349	RC07GF104J
R26	000272	RES	CARBON	2.7 K	5% 1/4W	81349	RC07GF272J
R27	000153	RES	CARBON	15 K	5% 1/4W	81349	RC07GF153J
R28	000510	RES	CARBON	51 OHM	5% 1/4W	81349	RC07GF510J
R29	000101	RES	CARBON	100 OHM	5% 1/4W	81349	RC07GF101J
R30	010533	RES	METAL	28.7 K	1% 1/10W	81349	RN55C2872F
R31	000103	RES	CARBON	10 K	5% 1/4W	81349	RC07GF103J
R32	000153	RES	CARBON	15 K	5% 1/4W	81349	RC07GF153J
R33	000153	RES	CARBON	15 K	5% 1/4W	81349	RC07GF153J
R34	000200	RES	CARBON	20 OHM	5% 1/4W	81349	RC07GF200J
R35	000513	RES	CARBON	51 K	5% 1/4W	81349	RC07GF513J
R36	000512	RES	CARBON	5.1 K	5% 1/4W	81349	RC07GF512J
R37	000103	RES	CARBON	10 K	5% 1/4W	81349	RC07GF103J
R38	000152	RES	CARBON	1.5 K	5% 1/4W	81349	RC07GF152J
R39	000332	RES	CARBON	3.3 K	5% 1/4W	81349	RC07GF332J
R40	000392	RES	CARBON	3.9 K	5% 1/4W	81349	RC07GF392J
R41	000202	RES	CARBON	2 K	5% 1/4W	81349	RC07GF202J
R42	000104	RES	CARBON	100 K	5% 1/4W	81349	RC07GF104J
R43	000104	RES	CARBON	100 K	5% 1/4W	81349	RC07GF104J
R44	000302	RES	CARBON	3 K	5% 1/4W	81349	RC07GF302J
R45	000152	RES	CARBON	1.5 K	5% 1/4W	81349	RC07GF152J
R46	000152	RES	CARBON	1.5 K	5% 1/4W	81349	RC07GF152J
R47	000202	RES	CARBON	2 K	5% 1/4W	81349	RC07GF202J
R48	000302	RES	CARBON	3 K	5% 1/4W	81349	RC07GF302J
R49	000104	RES	CARBON	100 K	5% 1/4W	81349	RC07GF104J
R50	000104	RES	CARBON	100 K	5% 1/4W	81349	RC07GF104J
R51	000104	RES	CARBON	100 K	5% 1/4W	81349	RC07GF104J
R52	000202	RES	CARBON	2 K	5% 1/4W	81349	RC07GF202J
R53	000103	RES	CARBON	10 K	5% 1/4W	81349	RC07GF103J
R54	000103	RES	CARBON	10 K	5% 1/4W	81349	RC07GF103J
R55	000101	RES	CARBON	100 OHM	5% 1/4W	81349	RC07GF101J
R56	000101	RES	CARBON	100 OHM	5% 1/4W	81349	RC07GF101J
R57	000273	RES	CARBON	27 K	5% 1/4W	81349	RC07GF273J
R58	001737	RES	CARBON	FSV	5% 1/4W	21793	001737
R59	000107	RES	CARBON	100 M	5% 1/4W	81349	RC07GF107J
R60	000104	RES	CARBON	100 K	5% 1/4W	81349	RC07GF104J
R61	001737	RES	CARBON	FSV	5% 1/4W	21793	001737
R62	000512	RES	CARBON	5.1 K	5% 1/4W	81349	RC07GF512J
R63	000208	RES	CARBON	2000 M	20% 1/4W	01121	CB2082

401609 – Assy., PCB, DIGITIZER continued

REF DES	RACAL-DANA P/N	DESCRIPTION	FSC	MANU P/N
R64	000686	RES CARBON 68 M 5% 1/4W	81349	RC07GF686J
R65	000106	RES CARBON 10 M 5% 1/4W	81349	RC07GF106J
R66	000225	RES CARBON 2.2 M 5% 1/4W	81349	RC07GF225J
R67	000511	RES CARBON 510 OHM 5% 1/4W	81349	RC07GF511J
R68	010520	RES METAL 21.5 K 1% 1/8W	81349	RN60D2152F
R69	000750	RES CARBON 75 OHM 5% 1/4W	81349	RC07GF750J
R70	000392	RES CARBON 3.9 K 5% 1/4W	81349	RC07GF392J
R71	000511	RES CARBON 510 OHM 5% 1/4W	81349	RC07GF511J
R72	000392	RES CARBON 3.9 K 5% 1/4W	81349	RC07GF392J
R73	000361	RES CARBON 360 OHM 5% 1/4W	81349	RC07GF361J
R74	001759	RES CARBON 5.1 OHM 5% 1/4W	81349	RC07GF5R1J
R75	040255	POT CERMET 10 OHM 20% .5W	73138	72XW10
T1	300087	TRANSFORMER, PULSE	21793	300087
T2	300087	TRANSFORMER, PULSE	21793	300087
T3	300087	TRANSFORMER, PULSE	21793	300087
TP1	600786	POST, MACHINE APPLIED STRIP	00779	1-87022-0
TP2	600786	POST, MACHINE APPLIED STRIP	00779	1-87022-0
TP3	600786	POST, MACHINE APPLIED STRIP	00779	1-87022-0
TP4	600786	POST, MACHINE APPLIED STRIP	00779	1-87022-0
TP5	600786	POST, MACHINE APPLIED STRIP	00779	1-87022-0
U1	230193	IC SN74LS00N	01295	SN74LS00N
U2	230193	IC SN74LS00N	01295	SN74LS00N
W1	600245	JUMPER, INSULATED		L-2007-1LP

401605 – Assy., PCB, ISOLATOR

REF DES	RACAL-DANA P/N	DESCRIPTION	FSC	MANU P/N
C1	120313	CAP POLY .15 MFD 200 V 5%	27556	PA2C154J
C2	120271	CAP POLY .5 MFD 50 V 5%	27556	PV2A504J
C3	101098	CAP CERAM 330 PFD 500 V 10%	56289	10TS-T33
C4	101099	CAP CERAM 680 PFD 1000 V 10%	71471	SCD2X5F
C5	120004	CAP POLY .001 MFD 500 V 5%	08257	KSO Series
C6	100040	CAP CERAM 200 PFD 1000 V 20%	56289	C023B102E201M
C7	121147	CAP MYLAR .0068 MFD 100 V 10%	09023	WMF1D68
C8	121394	CAP MYLAR ..15 MFD 100 V 10%	09023	WMF1P15
C9	120313	CAP POLY .15 MFD 200 V 5%	27556	PA2C154J
C10	121092	CAP MYLAR .0022 MFD 100 V 10%	09023	WFF1D22
C11	100032	CAP MICA 1300 PFD 100 V	72136	DM19F132J
C12	101145	CAP CERAM 100 PFD 500 V 10%	04222	TCD-DI-1N5600-100
C13	110129	CAP TANTA .1 MFD 35 V 20%	05397	T368A104M035AS
C14	100012	CAP CERAM 33 PFD 500 V 10%	71471	TCD-DI-1(N750)
C15	121147	CAP MYLAR .0068 PFD 100 V 10%	09023	WMF1D68
C16	100012	CAP CERAM 33 PFD 500 V 10%	71471	TCD-DI-1(N750)
C17	110126	CAP TANTA 6.8 MFD 35 V 20%	05397	T368B685M035AS
C18	110126	CAP TANTA 6.8 MFD 35 V 20%	05397	T368B685M035AS
C19	100012	CAP CERAM 33 PFD 500 V 10%	71471	TCD-DI-1(N750)
C21	101182	CAP CERAM 47 PFD 500 V 10%	71471	TCD-DI-2(N750)
C22	101182	CAP CERAM 47 PFD 500 V 10%	71471	TCD-DI-2(N750)
C23	100017	CAP CERAM .01 MFD 100 V 20%	56289	C023B101F103M
C24	100017	CAP CERAM .01 MFD 100 V 20%	56289	C023B101F103M
C25	110129	CAP TANTA .1 MFD 35 V 20%	05397	T368A104M035AS
C27	100012	CAP CERAM 33 PFD 500 V 10%	71471	TCD-DI-1(N750)
C30	101145	CAP CERAM 100 PFD 500 V 10%	04222	TCD-DI-1N5600-100
AR1	230411	IC OP AMP LM201A-H	27014	LM201A-H
AR2	230103	IC LM308	27014	LM308
AR3	230054	IC LM301A	27014	LM301A
AR4	230054	IC LM301A	27014	LM301A
AR5	230411	IC OP AMP LM201A-H	27014	LM201A-H
CR1	210004	DIODE SILICO 1N4004	81349	1N4004
CR2	210004	DIODE SILICO 1N4004	81349	1N4004
CR3	220026	DIODE ZENER 12 V 1N963B	81349	1N963B
CR4	220026	DIODE ZENER 12 V 1N963B	81349	1N963B
CR5	220035	DIODE ZENER 16 V 1N966B 5%	81349	1N966B
CR6	211083	DIODE SILICO 1N916B	81349	1N916B
CR7	220015	DIODE SILICO, ZENER 1N967B	81349	1N967B
CR8	220027	DIODE SILICO ZENER 4.3 V 1N749A	81349	1N749A
CR9	220027	DIODE SILICO ZENER 4.3 V	81349	1N749A
K1	310134	RELAY, MAGNETIC REED 2 Form A	15636	R6278-3
Q1	200200	TRANS NPN 200200	21793	200200

401605 – Assy., PCB, ISOLATOR continued

REF DES	RACAL-DANA P/N	DESCRIPTION					FSC	MANU P/N
Q2	200247	TRANS	FET	DUAL			21793	200247
Q3	200088	TRANS	SILICO	PNP	2N4248		80131	2N4248
Q5	200161	TRANS	DUAL FET		E-415		17856	E-415
Q6	200245	TRANS		PNP	MPS-A92		04713	MPS-A92
Q7	200233	TRANS	SILICO	NPN	MPS-A42		04713	MPS-A42
Q8	200200	TRANS		NPN	200200		21793	200200
Q9	200200	TRANS		NPN	200200		21793	200200
R1	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R2	000513	RES	CARBON	51 K		5% 1/4W	81349	RC07GF513J
R3	000513	RES	CARBON	51 K		5% 1/4W	81349	RC07GF513J
R4	012098	RES	METAL, PRECISION	25.5 K		.1% .05W	14298	UAR-1/10 C-6
R6	010529	RES	METAL	10 K		1% 1/10W	81349	RN55C1002F
R7	010536	RES	METAL	100 K		1% 1/10W	81349	RN55C1003F
R9	001737	RES	CARBON	FSV		5% 1/4W	21793	001737
R10	001737	RES	CARBON	FSV		5% 1/4W	21793	001737
R11	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R12	012098	RES	METAL, PRECISION	25.5 K		.1% .05W	81349	UAR-1/10C-6
R13	010106	RES	METAL	324 K	T-0	1% 1/8W	81349	RN60D3243F
R16	010106	RES	METAL	324 K	T-0	1% 1/8W	81349	RN60D3243F
R18	000151	RES	CARBON	150 OHM		5% 1/4W	81349	RC07GF151J
R19	000151	RES	CARBON	150 OHM		5% 1/4W	81349	RC07GF151J
R20	010536	RES	METAL	100 K		1% 1/10W	81349	RN55C1003F
R21	010621	RES	METAL	49.9 K		1% 1/10W	81349	RN55C4992F
R22	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R23	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R24	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R25	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R26	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R27	010529	RES	METAL	10 K		1% 1/10W	81349	RN55C1002F
R28	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R32	000200	RES	CARBON	20 OHM		5% 1/4W	81349	RC07GF200J
R33	010534	RES	METAL	34 K		1% 1/10W	81349	RN55C3402F
R34	040232	POT	CERMET	10 K		10%	73138	89PR10K
R35	001737	RES	CARBON	FSV		5% 1/4W	21793	001737
R36	001737	RES	CARBON	FSV		5% 1/4W	21793	001737
TP1	600786	POST, MACHINE APPLIED STRIP					00779	1-87022-0
TP2	600786	POST, MACHINE APPLIED STRIP					00779	1-87022-0
TP3	600786	POST, MACHINE APPLIED STRIP					00779	1-87022-0
TP4	600786	POST, MACHINE APPLIED STRIP					00779	1-87022-0

401610 – Assy., PCB, SWITCHING

REF DES	RACAL-DANA P/N	DESCRIPTION					FSC	MANU P/N
C1	120309	CAP	POLY	.015 MFD	200 V	5%	27556	PA2C153J
C2	120313	CAP	POLY	.15 MFD	200 V	5%	27556	PA2C154J
CR1	211083	DIODE	SILICO		1N916B		81349	1N916B
CR2	211083	DIODE	SILICO		1N916B		81349	1N916B
CR3	211083	DIODE	SILICO		1N916B		81349	1N916B
CR4	211083	DIODE	SILICO		1N916B		81349	1N916B
K1	310113	RELAY	REED		26 V		15636	R4092-3
K2	310112	RELAY			28 V		26806	AZ421-467-204
K3	310112	RELAY			28 V		26806	AZ421-467-204
K4	310112	RELAY			28 V		26806	AZ421-467-204
K5	310112	RELAY			28 V		26806	AZ421-467-204
K6	310112	RELAY			28 V		26806	AZ421-467-204
R1	001806	RES	CARBON	200 K		5% 2W	01121	See Description
R2	001806	RES	CARBON	200 K		5% 2W	01121	See Description
R4	010033	RES	METAL	49.9 K	T-0	1% 1/8W	81349	RN60D4992F

401603, 404171 – Assy., PCB, COMPUTER I

REF DES	RACAL-DANA P/N	DESCRIPTION					FSC	MANU P/N
C1	110126	CAP	TANTA	6.8 MFD	35 V	20%	05397	T368B685M035AS
C2	110126	CAP	TANTA	6.8 MFD	35 V	20%	05397	T368B685M035AS
C3	100017	CAP	CERMET	.01 MFD	100 V	20%	56289	C023B101F103M
C4	100017	CAP	CERMET	.01 MFD	100 V	20%	56289	C023B101F103M
C5	110126	CAP	TANTA	6.8 MFD	35 V	20%	05397	T368B685M035AS
C6	100017	CAP	CERMET	.01 MFD	100 V	20%	56289	C023B101F103M
C7	100017	CAP	CERMET	.01 MFD	100 V	20%	56289	C023B101F103M
R1	000473	RES	CARBON	47 K		5% 1/4W	81349	RC07GF473J
U1	230402	IC			74LS30N		27014	74LS30N
U2	230193	IC			SN74LS00N		01295	SN74LS00N
U3	230368	IC			74LS138		27014	74LS138
U4	230305	IC			SN74LS08		01295	SN74LS08
U5	230330	IC			74LS367		01295	74LS367
U6	230330	IC			74LS367		01295	74LS367
U7	230330	IC			74LS367		01295	74LS367
U8	230330	IC			74LS367		01295	74LS367
U9	230368	IC			74LS138		27014	74LS138
U10	230368	IC			74LS138		27014	74LS138
U11	230520	IC - Memory - U11					21793	230520
U12	230369	IC			6802-P		04713	6802-P
U13	230375	IC			AM9112APC			AM9112APC
U14	230375	IC			AM9112APC			AM9112APC
U15	230375	IC			AM9112APC			AM9112APC
U16	230375	IC			AM9112APC			AM9112APC
U17*	230523	IC - Memory - U17					21793	230523
U18	230400	IC	ROM	"U14"	S6831-U14		31471	S6831-U14
U19	230548	IC	ROM		2K x 8 – U19		21793	230548
U20	230522	IC - Memory - U20					21793	230522
U21	230521	IC - Memory - U21					21793	230521

*Used only in 404171

401604 – Assy., PCB, CONTROL LOGIC

REF DES	RACAL-DANA P/N	DESCRIPTION					FSC	MANU P/N
C1	110137	CAP	TANTA	.47 MFD	35 V	20%	05397	T368A474M035AS
C2	110137	CAP	TANTA	.47 MFD	35 V	20%	05397	T368A474M035AS
C3	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C4	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C5	110126	CAP	TANTA	6.8 MFD	35 V	20%	05397	T368B685M035AS
C6	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C7	120003	CAP	MYLAR	.1 MFD	100 V		09023	WMF1P1
C8	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C9	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C10	130144	CAP	MICA	270 PFD	100 V	5%	72136	DM10271J
C11	130162	CAP	MICA	33 PFD	500 V	5%	09023	CD6ED330J03
C12	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C13	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C14	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C15	100071	CAP	CERAM	.001 MFD	1000 V	20%	56289	C023B102E102M
C16	100068	CAP	CERAM	.02 MFD	100 V	20%	56289	C023B101H203M
CR1	211083	DIODE	SILICO		1N916B		81349	1N916B
Q1	200037	TRANS	SILICO	NPN	2N3646		80131	2N3646
Q2	200099	TRANS		PNP	2N4258		81349	2N4258
Q3	200037	TRANS	SILICO	NPN	2N3646		80131	2N3646
Q4	200099	TRANS		PNP	2N4258		81349	2N4258
Q5	230037	TRANS	SILICO	NPN	2N3646		80131	2N3646
Q6	200261	TRANS	SILICO	NPN	2N2369		81349	2N2369
Q7	230037	TRANS	SILICO	NPN	2N3646		80131	2N3646
Q8	230037	TRANS	SILICO	NPN	2N3646		80131	2N3646
Q9	200095	TRANS		NPN	2N3563		81349	2N3563
R1	000200	RES	CARBON	20 OHM		5% 1/4W	81349	RC07GF200J
R2	000200	RES	CARBON	20 OHM		5% 1/4W	81349	RC07GF200J
R3	000362	RES	CARBON	3.6 K		5% 1/4W	81349	RC07GF362J
R4	000562	RES	CARBON	5.6 K		5% 1/4W	81349	RC07GF562J
R5	000362	RES	CARBON	3.6 K		5% 1/4W	81349	RC07GF362J
R6	000682	RES	CARBON	6.8 K		5% 1/4W	81349	RC07GF682J
R7	000362	RES	CARBON	3.6 K		5% 1/4W	81349	RC07GF362J
R8	000562	RES	CARBON	5.6 K		5% 1/4W	81349	RC07GF562J
R9	000201	RES	CARBON	200 OHM		5% 1/4W	81349	RC07GF201J
R10	000201	RES	CARBON	200 OHM		5% 1/4W	81349	RC07GF201J
R11	000361	RES	CARBON	360 OHM		5% 1/4W	81349	RC07GF361J
R12	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R13	010828	RES	METAL	45.3 K		1% 1/10W	81349	RN55C4532F
R14	010618	RES	METAL	200 K		.25% 1/10W	81349	RN55C2003C
R15	000135	RES	CARBON	1.3 M		5% 1/4W	81349	RC07GF135J

401604 – Assy., PCB, CONTROL LOGIC continued

REF DES	RACAL-DANA P/N	DESCRIPTION	FSC	MANU P/N
R16	000205	RES CARBON 2 M 5% 1/4W	81349	RC07GF205J
R17	000102	RES CARBON 1 K 5% 1/4W	81349	RC07GF102J
R18	000102	RES CARBON 1 K 5% 1/4W	81349	RC07GF102J
R19	000151	RES CARBON 150 OHM 5% 1/4W	81349	RC07GF151J
R20	000682	RES CARBON 6.8 K 5% 1/4W	81349	RC07GF682J
R21	000562	RES CARBON 5.6 K 5% 1/4W	81349	RC07GF562J
R22	000331	RES CARBON 330 OHM 5% 1/4W	81349	RC07GF331J
TP1	600786	POST, MACHINE APPLIED STRIP	00779	1-87022-0
U1	230330	IC 74LS367	01295	74LS367
U2	230330	IC 74LS367	01295	74LS367
U3	230330	IC 74LS367	01295	74LS367
U4	230330	IC 74LS367	01295	74LS367
U5	230330	IC 74LS367	01295	74LS367
U6	230380	IC 74LS03	01295	74LS03
U7	230194	IC SN74LS74N	01295	SN74LS74N
U8	230193	IC SN74LS00N	01295	SN74LS00N
U9	230193	IC SN74LS00N	01295	SN74LS00N
U10	230368	IC 74LS138	27014	74LS138
U11	230363	IC LM555CN	27014	LM555CN
U12	230317	IC SN74LS90	01295	SN74LS90
U13	230317	IC SN74LS90	01295	SN74LS90
U14	230317	IC SN74LS90	01295	SN74LS90
U15	230383	IC 74LS490AN	01295	74LS490AN
U16	230383	IC 74LS490AN	01295	74LS490AN
U17	230194	IC SN74LS74N	01295	SN74LS74N
U18	230193	IC SN74LS00N	01295	SN74LS00N
U19	230193	IC SN74LS00N	01295	SN74LS00N
U20	230194	IC SN74LS74N	01295	SN74LS74N
U21	230194	IC SN74LS74N	01295	SN74LS74N
U22	230380	IC 74LS03	01295	74LS03
U23	230510	IC 74LS164		74LS164
U24	230313	IC CD4016AE	86884	CD4016AE
Y1	920811	CRYSTAL, SOLDER SEAL 24 MHz	27193	920811
Z1	080005	RES CERMET 10 K Network 6P,5R 2%	11236	750-61-R10KΩ

404019 – Assy., PARALLEL BCD OPTION

REF DES	RACAL-DANA P/N	DESCRIPTION	FSC	MANU P/N
U17	230407	IC ROM	31471	S6831B

401624 – Assy., PCB, PARALLEL BCD

REF DES	RACAL-DANA P/N	DESCRIPTION						FSC	MANU P/N
C1	100080	CAP	CERAM	.05 MFD	100 V	20%		56289	C023A101L503M
C2	100017	CAP	CERAM	.01 MFD	100 V	20%		56289	C023B101F103M
C3	110126	CAP	TANTA	6.8 MFD	35 V	20%		05397	T368B685M035AS
C4	100017	CAP	CERAM	.01 MFD	100 V	20%		56289	C023B101F103M
C5	100080	CAP	CERAM	.05 MFD	100 V	20%		56289	C023A101L503M
C6	100080	CAP	CERAM	.05 MFD	100 V	20%		56289	C023A101L503M
C7	100017	CAP	CERAM	.01 MFD	100 V	20%		56289	C023B101F103M
C8	100017	CAP	CERAM	.01 MFD	100 V	20%		56289	C023B101F103M
C9	110153	CAP	TANTA	.27 MFD	50 V	10%		05397	KR27P50K
C10	100017	CAP	CERAM	.01 MFD	100 V	20%		56289	C023B101F103M
C11	100017	CAP	CERAM	.01 MFD	100 V	20%		56289	C023B101F103M
C12	121091	CAP	MYLAR	.033 MFD	100 V	10%		09023	WMF1S33
C13	110165	CAP	TANTA	.15 MFD	35 V	10%		05397	T368A154K035AS
C14	110152	CAP	TANTA	.47 MFD	50 V	10%		05397	T368A474K050AS
C15	100017	CAP	CERMET	.01 MFD	100 V	20%		56289	C023B101F103M
P12	600930	CABLE ASSY			50 P			21793	600930
R1	000512	RES	CARBON	5.1 K		5%	1/4W	81349	RC07GF512J
R2	000512	RES	CARBON	5.1 K		5%	1/4W	81349	RC07GF512J
R3	000512	RES	CARBON	5.1 K		5%	1/4W	81349	RC07GF512J
R4	000512	RES	CARBON	5.1 K		5%	1/4W	81349	RC07GF512J
R5	000512	RES	CARBON	5.1 K		5%	1/4W	81349	RC07GF512J
R6	010609	RES	METAL	909 K		1%	1/8W	81349	RN60D9093F
U1	230366	INTEGRATED CIRCUIT			DM74LS174N			27014	DM74LS174N
U2	230366	INTEGRATED CIRCUIT			DM74LS174N			27014	DM74LS174N
U3	230356	INTEGRATED CIRCUIT			74LS175			27014	74LS175
U4	230368	INTEGRATED CIRCUIT			74LS138			27014	74LS138
U5	230194	INTEGRATED CIRCUIT			SN74LS74N			01295	SN74LS74N
U7	230193	INTEGRATED CIRCUIT			SN74LS00N			01295	SN74LS00N
U8	230064	INTEGRATED CIRCUIT			7404			01295	7404
U9	230193	INTEGRATED CIRCUIT			SN74LS00N			01295	SN74LS00N
U10	230366	INTEGRATED CIRCUIT			DM74LS174N			27014	DM74LS174N
U11	230366	INTEGRATED CIRCUIT			DM74LS174N			27014	DM74LS174N
U12	230366	INTEGRATED CIRCUIT			DM74LS174N			27014	DM74LS174N
U13	230368	INTEGRATED CIRCUIT			74LS138			27014	74LS138
U14	230330	INTEGRATED CIRCUIT			74LS367			01295	74LS367
U15	230330	INTEGRATED CIRCUIT			74LS367			01295	74LS367
U16	230330	INTEGRATED CIRCUIT			74LS367			01295	74LS367
U17	230354	INTEGRATED CIRCUIT			74LS75			18324	74LS75

401624 – Assy., PCB, PARALLEL BCD *(continued)*

REF DES	RACAL-DANA P/N	DESCRIPTION					FSC	MANU P/N
U18	230354	INTEGRATED CIRCUIT			74LS75		18324	74LS75
U19	230354	INTEGRATED CIRCUIT			74LS75		18324	74LS75
U20	230193	INTEGRATED CIRCUIT			SN74LS00N		01295	SN74LS00N
U21	230064	INTEGRATED CIRCUIT			7404		01295	7404
U22	230248	INTEGRATED CIRCUIT			SN74LS10N		01295	SN74LS10N
U23	230313	INTEGRATED CIRCUIT			CD4016AE		86884	CD4016AE
U24	230194	INTEGRATED CIRCUIT			SN74LS74N		01295	SN74LS74N
U25	230363	INTEGRATED CIRCUIT			LM555CN		27014	LM555CN
Z1	080004	RES	CERMET	4.7 K	NETWORK 6P,5R	2%	11236	750-61-R4.7KΩ
Z2	080004	RES	CERMET	4.7 K	NETWORK 6P,5R	2%	11236	750-61-R4.7KΩ
Z3	080004	RES	CERMET	4.7 K	NETWORK 6P,5R	2%	11236	750-61-R4.7KΩ
Z4	080023	RES	CERMET	4.7 K	NETWORK 8P,7R	2%	11236	750-81-R4.7KΩ
Z5	080004	RES	CERMET	4.7 K	NETWORK 6P,5R	2%	11236	750-61-R4.7KΩ

404020 – Assy., CABLE, PARALLEL BCD, 25 PIN

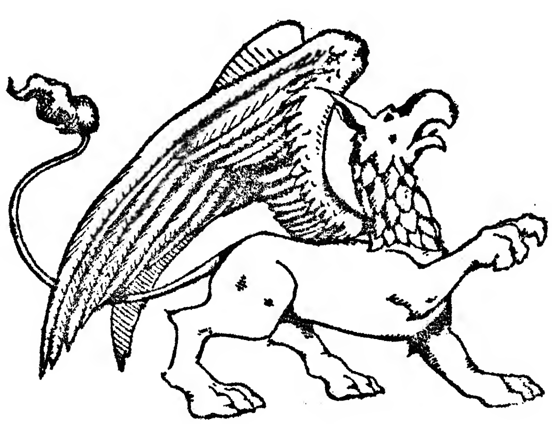
REF DES	RACAL-DANA P/N	DESCRIPTION	FSC	MANU P/N
J209	600167	CONN 25 S	71785	DB-25S

REF DES	RACAL-DANA P/N	DESCRIPTION					FSC	MANU P/N
AR1	230054	IC					27014	LM301A
AR2	230415	IC	HIGH VOLTAGE OP AMP				27014	LM343H
C1	101175	CAP	CERAM	220 PFD	500 V	10%	71471	SCD1X5F
C2	101175	CAP	CERAM	220 PFD	500 V	10%	71471	SCD1X5F
C3	100012	CAP	CERAM	33 PFD	500 V	10%	71471	TCD-DI-1(N750)
C4	101174	CAP	CERAM	.001 MFD	500 V	10%	04222	SCD-DI-2X5F-1000
C5	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C6	101174	CAP	CERAM	.001 MFD	500 V	10%	04222	SCD-DI-2X5F-1000
C7	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C8	101145	CAP	CERAM	100 PFD	500 V	10%	04222	TCD-DI-1N5600-100
C9	101174	CAP	CERAM	.001 MFD	500 V	10%	04222	SCD-DI-2X5F-1000
C10	120290	CAP	MYLAR	.22 MFD	100 V	20%	73445	C281AH/A220K
C11	120036	CAP	POLY	3300 PFD	630 V	5%	08257	CPR-330J
CR1	211083	DIODE	SILICO		1N916B		81349	1N916B
CR2	211083	DIODE	SILICO		1N916B		81349	1N916B
CR3	211083	DIODE	SILICO		1N916B		81349	1N916B
CR4	211083	DIODE	SILICO		1N916B		81349	1N916B
CR5	210014	DIODE			1N4005		81349	1N4005
CR6	211083	DIODE	SILICO		1N916B		81349	1N916B
CR7	211083	DIODE	SILICO		1N916B		81349	1N916B
CR8	220015	DIODE	SILICO, ZENER		1N967B		81349	1N967B
K1	310136	RELAY, MAGNETIC REED			1 Form A		15636	R6277-3
K2	310134	RELAY, MAGNETIC REED			2 Form A		15636	R6278-3
K3	310134	RELAY, MAGNETIC REED			2 Form A		15636	R6278-3
K4	310112	RELAY		28 V	AZ421-467-204		26806	AZ421-467-204
K5	310112	RELAY		28 V	AZ421-467-204		26806	AZ421-467-204
Q1	200201	TRANS	Dual	NPN	200201		21793	200201
Q2	200200	TRANS		NPN	200200		21793	200200
Q3	200200	TRANS		NPN	200200		21793	200200
Q4	200088	TRANS	SILICO	PNP	2N4248		80131	2N4248
Q5	200068	TRANS		PNP	2N4250		80131	2N4250
Q6	200068	TRANS		PNP	2N4250		80131	2N4250
Q7	200068	TRANS		PNP	2N4250		80131	2N4250
Q8	200200	TRANS		NPN	200200		21793	200200
Q9	200200	TRANS		NPN	200200		21793	200200
Q10	200245	TRANS		PNP	MPS-A92		04713	MPS-A92
Q11	200245	TRANS		PNP	MPS-A92		04713	MPS-A92

REF DES	RACAL-DANA P/N	DESCRIPTION					FSC	MANU P/N
Q12	200200	TRANS		NPN	200200		21793	200200
Q13	200200	TRANS		NPN	200200		21793	200200
Q14	200247	TRANS		DUAL J-FET	5μV/°C		21793	200247
Q15	200088	TRANS	SILICO	PNP	2N4248		80131	2N4248
Q16	200200	TRANS		NPN	200200		21793	200200
Q17	200245	TRANS		PNP	MPS-A92		04713	MPS-A92
Q18	200245	TRANS		PNP	MPS-A92		04713	MPS-A92
Q19	200200	TRANS		NPN	200200		21793	200200
Q20	200088	TRANS	SILICO	PNP	2N4248		80131	2N4248
R1	010780	RES	METAL	499 K		1% 1/8W	81349	RN60E4993F
R2	010780	RES	METAL	499 K		1% 1/8W	81349	RN60E4993F
R3	000203	RES	CARBON	20 K		5% 1/4W	81349	RC07GF203J
R4	010784	RES	CARBON	4.7 M		1%	91637	DC1-4
R5	000202	RES	CARBON	2 K		5% 1/4W	81349	RC07GF202J
R6	001816	RES	CARBON	47 K		5% 2W	01121	See Description
R7	001816	RES	CARBON	47 K		5% 2W	01121	See Description
R10	010118	RES	METAL	56.2 K	T-0	1% 1/8W	81349	RN60D5622F
R11	000203	RES	CARBON	20 K		5% 1/4W	81349	RC07GF203J
R12	000205	RES	CARBON	2 M		5% 1/4W	81349	RC07GF205J
R13	000205	RES	CARBON	2 M		5% 1/4W	81349	RC07GF205J
R14	000205	RES	CARBON	2 M		5% 1/4W	81349	RC07GF205J
R15	000205	RES	CARBON	2 M		5% 1/4W	81349	RC07GF205J
R16	040229	POT	CERMET	1 K		10% 3/4W	73138	89PR1K
R17	000473	RES	CARBON	47 K		5% 1/4W	81349	RC07GF473J
R18	000221	RES	CARBON	220 OHM		5% 1/4W	81349	RC07GF221J
R19	000221	RES	CARBON	220 OHM		5% 1/4W	81349	RC07GF221J
R20	000104	RES	CARBON	100 K		5% 1/4W	81349	RC07GF104J
R21	000104	RES	CARBON	100 K		5% 1/4W	81349	RC07GF104J
R22	000753	RES	CARBON	75 K		5% 1/4W	81349	RC07GF753J
R23	010118	RES	METAL	56.2 K	T-0	1% 1/8W	81349	RN60D5622F
R24	000112	RES	CARBON	1.1 K		5% 1/4W	81349	RC07GF112J
R25	000393	RES	CARBON	39 K		5% 1/4W	81349	RC07GF393J
R26	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R27	000102	RES	CARBON	1 K		5% 1/4W	81349	RC07GF102J
R28	001816	RES	CARBON	47 K		5% 2W	01121	See Description
R29	010337	RES	CARBON	10 M		1% 1/2W	81349	RN20X1005F
W1	600245	JUMPER	INSULATED					L-2007-1LP
W2	600245	JUMPER	INSULATED					L-2007-1LP
W3	600245	JUMPER	INSULATED					L-2007-1LP

401607 – Assy., PCB, OHMS REFERENCE

REF DES	RACAL-DANA P/N	DESCRIPTION	FSC	MANU P/N
AR1	230054	IC LM301A	27014	LM301A
C1	100012	CAP CERAM 33 PFD 500 V 10%	71471	TCD-DI-1(N750)
K1	310134	RELAY MAGNETIC REED 2 Form A	15636	R6278-3
R1	010656	RES METAL 19.948 M .1% 1/2W	81349	RN70E Type
R2	020716	RES WW 10 K .1% .05W	22045	J90
R3	010719	RES METAL 16.2 K 1% 1/10W	81349	RN55C1622F
R4	020719	RES WW 20 K .1% .05W	22045	J90
R5	020716	RES W 10 K .1% .05W	22045	J90
R6	010655	RES METAL 11.086 M .1% 1/2W	81349	RN70E Type
R7	000470	RES CARBON 47 OHM 5% 1/4W	81349	RC07GF470J
R8	020712	RES WW 112.5 K .01% .15W	22045	J110
R9	020699	RES WW 4.0004 K .01% .15W	22045	J110
R10	020612	RES WW 1.009 M .05% 1/4W	22045	J120
R11	020698	RES WW 445.71 OHM .05% .15W	22045	J110
R12	001759	RES CARBON 5.1 OHM 5% 1/4W	81349	RC07GF5R1J
R13	020718	RES WW 2 K .1% .05W	22045	J90
R15	012038	RES METAL 10 K .1% .3W	18612	HP-202
R16	020707	RES WW 5 K .02% .15W	22045	J110
R17	020708	RES WW 20 K .05% .15W	22045	J110
W1	600245	JUMPER INSULATED		L-2007-1LP



401619 – Assy., PCB, AVERAGING AC CONVERTER

REF DES	RACAL-DANA P/N	DESCRIPTION					FSC	MANU P/N
AR1	230103	IC			LM308		27014	LM308
AR2	230103	IC			LM308		27014	LM308
AR3	230054	IC			LM301A		27014	LM301A
B1	920563	BEADS	SHIELDING				02114	56-59065/4B
B2	920563	BEADS	SHIELDING				02114	56-59065/4B
C1	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C2	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C3	110126	CAP	TANTA	6.8 MFD	35 V	20%	05397	T368B685M035AS
C4	100081	CAP	CERAM	4.7 PFD	1000 V	5%	56289	C030B102E4R7D
C5	121394	CAP	MYLAR	.15 MFD	100 V	10%	09023	WMF1P15
C6	121394	CAP	MYLAR	.15 MFD	100 V	10%	09023	WMF1P15
C7	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C8	100095	CAP	CERAM	2.7 ± .5 PFD	1000 V		56289	C030B102S2R7D
C9	120130	CAP	MYLAR	.15 MFD	100 V	5%	27556	XT2B154J
C10	120025	CAP	MYLAR	1.5 MFD	100 V	10%	27556	XA2B155K
C11	110126	CAP	TANTA	6.8 MFD	35 V	20%	05397	T368B685M035AS
C12	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C13	130131	CAP	TRIMMER	2-20 PFD	100 V		73445	C010KA/20E
C14	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C15	100095	CAP	CERAM	2.7 ± .5 PFD	1000 V		56289	C030B102S2R7D
C16	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C17	110126	CAP	TANTA	6.8 MFD	35 V	20%	05397	T368B685M035AS
C18	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C19	100012	CAP	CERAM	33 PFD	500 V	10%	71471	TCD-DI-1(N750)
C20	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C21	100012	CAP	CERAM	33 PFD	500 V	10%	71471	TCD-DI-1(N750)
C22	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C23	100012	CAP	CERAM	33 PFD	500 V	10%	71471	TCD-DI-1(N750)
C24	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C25	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C26	100038	CAP	CERAM	560 PFD	500 V	10%	71590	DD561
C27	110126	CAP	TANTA	6.8 MFD	35 V	20%	05397	T368B685M035AS
C28	110125	CAP	TANTA	2.2 MFD	35 V	20%	05397	T368B225M035AS
C29	100038	CAP	CERAM	560 PFD	500 V	10%	71590	DD561
C30	110181	CAP	TANTA	47 MFD	25 V		05397	T36D476025A
C31	110181	CAP	TANTA	47 MFD	25 V		05397	T36D476025A
CR1	220004	DIODE	SILICO, ZENER		1N961B		81349	1N961B
CR2	210035	DIODE	HOT CARRIER		HP5082-2810		50434	HP5082-2810
CR3	210035	DIODE	HOT CARRIER		HP5082-2810		50434	HP5082-2810

401619 – Assy., PCB, AVERAGING AC CONVERTER continued

REF DES	RACAL-DANA P/N	DESCRIPTION					FSC	MANU P/N
CR4	220004	DIODE	SILICO, ZENER		1N961B		81349	1N961B
CR5	220035	DIODE	ZENER		16V	5%	81349	1N966B
CR6	220035	DIODE	ZENER		16V	5%	81349	1N966B
Q1	200197	TRANS	SILICO	NPN	MPS-H10		04713	MPS-H10
Q2	200197	TRANS	SILICO	NPN	MPS-H10		04713	MPS-H10
Q3	200178	TRANS		PNP	2N5910		81349	2N5910
Q4	200197	TRANS	SILICO	NPN	MPS-H10		04713	MPS-H10
Q5	200197	TRANS	SILICO	NPN	MPS-H10		04713	MPS-H10
Q6	200197	TRANS	SILICO	NPN	MPS-H10		04713	MPS-H10
Q7	200200	TRANS		NPN	200200		21793	200200
Q8	200201	TRANS	DUAL	NPN	200201		21793	200201
Q9	200201	TRANS	DUAL	NPN	200201		21793	200201
Q10	200200	TRANS		NPN	200200		21793	200200
Q11	200200	TRANS		NPN	200200		21793	200200
Q12	200200	TRANS		NPN	200200		21793	200200
Q13	200068	TRANS		PNP	2N4250		80131	2N4250
Q14	200179	TRANS		FET	KE4391		27014	KE4391
Q15	200178	TRANS		PNP	2N5910		81349	2N5910
R1	000333	RES	CARBON	33 K		5% 1/4W	81349	RC07GF333J
R2	000201	RES	CARBON	200 OHM		5% 1/4W	81349	RC07GF201J
R3	000510	RES	CARBON	51 OHM		5% 1/4W	81349	RC07GF510J
R4	000512	RES	CARBON	5.1 K		5% 1/4W	81349	RC07GF512J
R5	000751	RES	CARBON	750 OHM		5% 1/4W	81349	RC07GF751J
R6	000163	RES	CARBON	16 K		5% 1/4W	81349	RC07GF163J
R7	000113	RES	CARBON	11 K		5% 1/5W	81349	RC07GF113J
R8	000562	RES	CARBON	5.6 K		5% 1/4W	81349	RC07GF562J
R9	000100	RES	CARBON	10 OHM		5% 1/4W	81349	RC07GF100J
R10	000105	RES	CARBON	1 M		5% 1/4W	81349	RC07GF105J
R11	000161	RES	CARBON	160 OHM		5% 1/4W	81349	RC07GF161J
R12	000333	RES	CARBON	33 K		5% 1/4W	81349	RC07GF333J
R13	000183	RES	CARBON	18 K		5% 1/4W	81349	RC07GF183J
R14	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R15	010529	RES	METAL	10 K		1% 1/10W	81349	RN55C1002F
R16	000107	RES	CARBON	100 M		5% 1/4W	81349	RC07GF107J
R17	000911	RES	CARBON	910 OHM		5% 1/4W	81349	RC07GF911J
R18	000101	RES	CARBON	100 OHM		5% 1/4W	81349	RC07GF101J
R19	000153	RES	CARBON	15 K		5% 1/4W	81349	RC07GF153J
R20	000101	RES	CARBON	100 OHM		5% 1/4W	81349	RC07GF101J

401619 – Assy., PCB, AVERAGING AC CONVERTER continued

REF DES	RACAL-DANA P/N	DESCRIPTION				FSC	MANU P/N
R21	010727	RES	METAL	2.5 K	.01%	18612	V53-1M
R22	000332	RES	CARBON	3.3 K	5% 1/4W	81349	RC07GF332J
R23	000103	RES	CARBON	10 K	5% 1/4W	81349	RC07GF103J
R24	020657	RES	WW	11.109 K	.01% .15W	22045	J110
R25	010536	RES	METAL	100 K	1% 1/10W	81349	RN55C1003F
R26	010631	RES	METAL	10.2 K	1% 1/10W	81349	RN55C1022F
R27	000124	RES	CARBON	120 K	5% 1/4W	81349	RC07GF124J
R28	000106	RES	CARBON	10 M	5% 1/4W	81349	RC07GF106J
R29	010808	RES	METAL	10 K	.1% 1/10W	81349	RN55C1002B
R30	000201	RES	CARBON	200 OHM	5% 1/4W	81349	RC07GF201J
R31	000101	RES	CARBON	100 OHM	5% 1/4W	81349	RC07GF101J
R32	000102	RES	CARBON	1 K	5% 1/4W	81349	RC07GF102J
R33	010660	RES	METAL	5 K	.01%	18612	V53-1
R34	000151	RES	CARBON	150 OHM	5% 1/4W	81349	RC07GF151J
R35	000821	RES	CARBON	820 OHM	5% 1/4W	81349	RC07GF821J
R36	000101	RES	CARBON	100 OHM	5% 1/4W	81349	RC07GF101J
R37	010661	RES	METAL	10 K	.01%	18612	V53-1M
R38	010529	RES	METAL	10 K	1% 1/10W	81349	RN55C1002F
R39	010829	RES	METAL	4.99 K	1% 1/10W	81349	RN55C4991F
R40	040234	POT	CERMET	50 K	10%	73138	89PR50K
R41	010650	RES	METAL	1 M	1% 1/10W	81349	RN55E1004F
R42	000103	RES	CARBON	10 K	5% 1/4W	81349	RC07GF103J
R43	010650	RES	METAL	1 M	1% 1/10W	81349	RN55E1004F
R44	010650	RES	METAL	1 M	1% 1/10W	81349	RN55E1004F
R45	010650	RES	METAL	1 M	1% 1/10W	81349	RN55E1004F
R46	040234	POT	CERMET	50 K	10%	73138	89PR50K
R47	000105	RES	CARBON	1 M	5% 1/4W	81349	RC07GF105J
R48	001159	RES	CARBON	330 OHM	5% 1/2W	81349	RC07GF331J
R49	001159	RES	CARBON	330 OHM	5% 1/2W	81349	RC07GF331J
R50	040235	POT	CERMET	100 K	10% 3/4W	73138	89PR100K
TP1	600591	POST	TEST POINT			00779	85931-6
TP2	600591	POST	TEST POINT			00779	85931-6
TP3	600591	POST	TEST POINT			00779	85931-6
TP4	600591	POST	TEST POINT			00779	85931-6
TP5	600591	POST	TEST POINT			00779	85931-6
TP6	600591	POST	TEST POINT			00779	85931-6
TP7	600591	POST	TEST POINT			00779	85931-6

401626 – Assy., PCB, 4-WIRE RATIO

REF DES	RACAL-DANA P/N	DESCRIPTION						FSC	MANU P/N
AR1	230103	INTEGRATED CIRCUIT			LM308			27014	LM308
AR2	230103	INTEGRATED CIRCUIT			LM308			27014	LM308
AR3	230127	INTEGRATED CIRCUIT			SSS725C			06665	SSS725C
C1	110126	CAP	TANTA	6.8 MFD	35 V	20%		05397	T363B685M035AS
C2	100017	CAP	CERAM	.01 MFD	100 V	20%		56289	C023B101F103M
C3	100017	CAP	CERAM	.01 MFD	100 V	20%		56289	C023B101F103M
C4	110126	CAP	TANTA	6.8 MFD	35 V	20%		05397	T368B685M035AS
C5	100012	CAP	CERAM	33 PFD	500 V	10%		71471	TOD-DI-1 (N750)
C6	120312	CAP	POLY	.022 MFD	400 V	10%		73445	C280MAF/A22K
C7	120308	CAP	POLY	.047 MFD	250 V	10%		73445	C280MAE/A47K
C8	100012	CAP	CERAM	33 PFD	500 V	10%		71471	TCD-DI-1(N750)
C9	100017	CAP	CERAM	.01 MFD	100 V	20%		56289	C023B101F103M
C10	110158	CAP	TANTA	10 MFD	50 V	10%		05397	T362C106K050A
Q1	200200	TRANS	NPN		200200			21793	200200
Q2	200200	TRANS	NPN		200200			21793	200200
R1	000390	RES	CARBON	39 OHM		5%	1/4W	81349	RC07GF390J
R2	000100	RES	CARBON	10 OHM		5%	1/4W	81349	RC07GF100J
R3	010033	RES	METAL	49.9 K	T-O	1%	1/8W	81349	RN60D4992F
R4	010033	RES	METAL	49.9 K	T-O	1%	1/8W	81349	RN60D4992F
R6	010787	RES	METAL	20 K		.02%		18612	V53-1
R7	010787	RES	METAL	20 K		.02%		18612	V53-1
R8	010033	RES	METAL	49.9 K	T-O	1%	1/8W	81349	RN60D4992F
R9	010787	RES	METAL	20 K		.02%		18612	V53-1
R10	000100	RES	CARBON	10 OHM		5%	1/4W	81349	RC07GF100J
R11	040229	POT	CERAM	1 K		10%	3/4W	73138	89PR1K
R12	040235	POT	CERAM	100 K		10%	3/4W	73138	89PR100K
R13	010033	RES	METAL	49.9 K	T-O	1%	1/8W	81349	RN60D4992F
R14	000100	RES	CARBON	10 OHM		5%	1/4W	81349	RC07GF100J
R15	040229	POT	CERAM	1 K		10%	3/4W	73138	89PR1K
R16	010787	RES	METAL	20 K		.02%		18612	V53-1

401618 – Assy., PCB, RMS CONVERTER

REF DES	RACAL-DANA P/N	DESCRIPTION					FSC	MANU P/N
AR1	230054	IC			LM301A		27014	LM301A
AR2	230180	IC	OP AMP		LM318H		27014	LM318H
B1	920563	BEADS	SHIELDING				02114	56-59065/4B
C1	101174	CAP	CERAM	.001 MFD	500 V	10%	04222	SCD-DI-2X5F-1000
C2	101642	CAP	CERAM	150 PFD	500 V	10%	71471	SCD1X5F
C3	120026	CAP	MYLAR	.47 MFD	100 V	10%	27556	SA2B474K
C4	100100	CAP	CERAM	FSV			21793	100100
C5	130160	CAP	MICA	330 PFD			72136	DM15 Series
C6	110151	CAP	TANTA	10 MFD	35 V	20%	05397	T362C106M035AS
C7	120026	CAP	MYLAR	.47 MFD	100 V	10%	27556	SA2B474K
C8	130076	CAP	MICA	200 PFD	500 V	5%	72136	DM15-201J
C9	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C10	101641	CAP	CERAM	470 PFD	500 V	10%	71471	SCD1X5F
C11	100100	CAP	CERAM	FSV			21793	100100
C12	130095	CAP	MICA	390 PFD	100 V	5%	72136	SCDM10-391J
C13	120280	CAP	MYLAR	.22 MFD	1000 V	10%	27556	ZA2J224K
C15	110151	CAP	TANTA	10 MFD	35 V	20%	05397	T362C106M035AS
C16	100100	CAP	CERAM	FSV			21793	100100
C17	120286	CAP	MYLAR	.1 MFD	100 V	20%	73445	C281AH/A100K
C18	101641	CAP	CERAM	470 MFD	500 V	10%	71471	SCD1X5F
C19	120026	CAP	MYLAR	.47 MFD	100 V	10%	27556	SA2B474K
C20	110126	CAP	TANTA	6.8 MFD	35 V	20%	05397	T368B685M035AS
C21	101641	CAP	CERAM	470 MFD	500 V	10%	71471	SCD1X5F
C22	101098	CAP	CERAM	330 PFD	500 V	10%	56289	10TS-T33
C23	130124	CAP	TRIMMER	1.2-10 PFD	250 V		52763	R-TR1K0-12209SD
C24	130123	CAP	TRIMMER	1-3 PFD	250 V		52763	R-TR1K0-122-09SD
C25	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C26	100050	CAP	CERAM	2.2 PFD	1000 V	5%	56289	C030B102S2R2D
C27	130146	CAP	TRIMMER	.25-1.5 PFD			74970	273-0001-002
C28	130146	CAP	TRIMMER	.25-1.5 PFD			74970	273-0001-002
C29	130116	CAP	MICA	3900 PFD	500 V	2%	72136	DM19F392G0
C30	100052	CAP	CERAM	22 PFD	1000 V	5%	56289	C030B102F220J
C31	100084	CAP	CERAM	1.5 ± .5 PFD	1000 V		56289	C030B102S1R5D
C32	110151	CAP	TANTA	10 MFD	35 V	20%	05397	T362C106M035AS
C33	110151	CAP	TANTA	10 MFD	35 V	20%	05397	T362C106M035AS
C34	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C35	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C36	110126	CAP	TANTA	6.8 MFD	35 V	20%	05397	T368B685M035AS
C37	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C38	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M

401618 – Assy., PCB, RMS CONVERTER continued

REF DES	RACAL-DANA P/N	DESCRIPTION	FSC	MANU P/N
C39	110162	CAP TANTA .33 MFD 35 V 5%	05397	T368A334J035AB
C40	110162	CAP TANTA .33 MFD 35 V 5%	05397	T368A334J035AB
CR1	220022	DIODE SILICO, ZENER 1N965B	81349	1N965B
CR2	210035	DIODE HOT CARRIER HP5082-2810	50434	HP5082-2810
CR3	210035	DIODE HOT CARRIER HP5082-2810	50434	HP5082-2810
K1	310078	RELAY REED 28 V	15636	R2690-3
K2	310078	RELAY REED 28 V	15636	R2690-3
K3	310078	RELAY REED 28 V	15636	R2690-3
K4	310078	RELAY REED 28 V	15636	R2690-3
Q1	200068	TRANS PNP 2N4250	80131	2N4250
Q2	403865	MATCHED LOG TRANSISTOR ASSY	21793	403865
Q3	403865	MATCHED LOG TRANSISTOR ASSY	21793	403865
Q4	200201	TRANS DUAL NPN	21793	200201
Q5	200199	TRANS FET FM1302	27014	FM1302
Q6	200068	TRANS PNP 2N4250	80131	2N4250
Q7	200200	TRANS NPN 200200	21793	200200
Q8	200264	TRANS SILICO DUAL PNP MP351		MP351
Q9	200200	TRANS NPN 200200	21793	200200
Q11	200197	TRANS SILICO NPN MPS-H10	04713	MPS-H10
Q12	200197	TRANS SILICO NPN MPS-H10	04713	MPS-H10
Q13	200200	TRANS NPN 200200	21793	200200
Q14	200200	TRANS NPN 200200	21793	200200
Q15	200220	TRANS DUAL 200220	21793	200220
Q16	200068	TRANS PNP 2N4250	80131	2N4250
Q17	200136	TRANS SILICO NPN 2N5963	81349	2N5963
R1	020667	RES WW 100 K .1% .15W	22045	J110
R2	000104	RES CARBON 100 K 5% 1/4W	81349	RC07GF104J
R3	403865	MATCHED LOG TRANSISTOR ASSY	21793	403865
R4	010618	RES METAL 200 K .25% 1/10W	81349	RN55C2003C
R5	010536	RES METAL 100 K 1% 1/10W	81349	RN55C1003F
R6	010542	RES METAL 100 K 1% 1/10W	81349	RN55E1003F
R7	000183	RES CARBON 18 K 5% 1/4W	81349	RC07GF183J
R8	000101	RES CARBON 100 OHM 5% 1/4W	81349	RC07GF101J
R9	000682	RES CARBON 6.8 K 5% 1/4W	81349	RC07GF682J
R10	010496	RES METAL 1 M 1% 1/8W	81349	RN60D1004F
R11	000104	RES CARBON 100 K 5% 1/4W	81349	RC07GF104J

401618 – Assy., PCB, RMS CONVERTER continued

REF DES	RACAL-DANA P/N	DESCRIPTION				FSC	MANU P/N
R12	001737	RES	CARBON	FSV	5% 1/4W	21793	001737
R13	010721	RES	METAL	DIAC, MATCHED SET		21793	010721
R14	000242	RES	CARBON	2.4 K	5% 1/4W	81349	RC07GF242J
R15	010721	RES	METAL	DIAC, MATCHED SET		21793	010721
R16	010542	RES	METAL	100 K	1% 1/10W	81349	RN55E1003F
R17	010611	RES	METAL	52.3 K	1% 1/10W	81349	RN55C5232F
R18	000392	RES	CARBON	3.9 K	5% 1/4W	81349	RC07GF392J
R19	010621	RES	METAL	49.9 K	1% 1/10W	81349	RN55C4992F
R20	000103	RES	CARBON	10 K	5% 1/4W	81349	RC07GF103J
R21	010533	RES	METAL	28.7 K	1% 1/10W	81349	RN55C2872F
R22	000476	RES	CARBON	47 M	5% 1/4W	81349	RC07GF476J
R23	000512	RES	CARBON	5.1 K	5% 1/4W	81349	RC07GF512J
R24	000107	RES	CARBON	100 M	5% 1/4W	81349	RC07GF107J
R25	403865	MATCHED LOG TRANSISTOR ASSY				21793	403865
R26	000681	RES	CARBON	680 OHM	5% 1/4W	81349	RC07GF681J
R27	000101	RES	CARBON	100 OHM	5% 1/4W	81349	RC07GF101J
R28	000123	RES	CARBON	12 K	5% 1/4W	81349	RC07GF123J
R29	000272	RES	CARBON	2.7 K	5% 1/4W	81349	RC07GF272J
R30	000101	RES	CARBON	100 OHM	5% 1/4W	81349	RC07GF101J
R31	010684	RES	METAL	487 OHM	1% 1/10W	81349	RN55E4870F
R32	000105	RES	CARBON	1 M	5% 1/4W	81349	RC07GF105J
R33	010684	RES	METAL	487 OHM	1% 1/10W	81349	RN55E4870F
R34	010721	RES	METAL	DIAC, MATCHED SET		21793	010721
R35	000820	RES	CARBON	82 OHM	5% 1/4W	81349	RC07GF820J
R36	010721	RES	METAL	DIAC, MATCHED SET		21793	010721
R37	001737	RES	CARBON	FSV	5% 1/4W	21793	001737
R38	001737	RES	CARBON	FSV	5% 1/4W	21793	001737
R39	010654	RES	METAL	20 K	.05%	18612	V53-1
R40	010586	RES	METAL	5 K	.02%	18612	V53-1M
R41	001737	RES	CARBON	FSV	5% 1/4W	21793	001737
R42	000101	RES	CARBON	100 OHM	5% 1/4W	81349	RC07GF101J
R43	010721	RES	METAL	DIAC, MATCHED SET		21793	010721
R44	010720	RES	METAL	9.09 K	.25% 1/10W	81349	RN55C9091C
R45	040227	POT	CERMET	200 OHM	10% 3/4W	73138	89PR200
R46	010654	RES	METAL	20 K	.05%	18612	V53-1
R47	010615	RES	METAL	10 K	.02 %	18612	V53-1M
R48	001737	RES	CARBON	FSV	5% 1/4W	21793	001737
R49	001737	RES	CARBON	FSV	5% 1/4W	21793	001737
R50	000513	RES	CARBON	51 K	5% 1/4W	81349	RC07GF513J
R51	001878	RES	CARBON	FSV	5% 1/4W	21793	001878
R52	040225	POT	CERMET	50 OHM	20%	73138	89PR50

401618 – Assy., PCB, RMS CONVERTER continued

REF DES	RACAL-DANA P/N	DESCRIPTION				FSC	MANU P/N
R53	040239	POT	CERMET	1 M	20%	73138	89PR1M
R54	040231	POT	CERMET	5 K	10%	73138	89PR5K
R55	040225	POT	CERMET	50 OHM	20%	73138	89PR50
R56	000101	RES	CARBON	100 OHM	5% 1/4W	81349	RC07GF101J
R57	000470	RES	CARBON	47 OHM	5% 1/4W	81349	RC07GF470J
R58	010615	RES	METAL	10 K	.02%	18612	V53-1M
R59	010586	RES	METAL	5 K	.02%	18612	V53-1M
R60	010654	RES	METAL	20 K	.05%	18612	V53-1
R61	000184	RES	CARBON	180 K	5% 1/4W	81349	RC07GF184J
R62	040235	POT	CERMET	100 K	10% 3/4W	73138	89PR100K
R63	040225	POT	CERMET	50 OHM	20%	73138	89PR50
R64	040225	POT	CERMET	50 OHM	20%	73138	89PR50
R65	040228	POT	CERMET	500 OHM	10%	73138	89PR500
R67	040228	POT	CERMET	500 OHM	10%	73138	89PR500
R69	001737	RES	CARBON	FSV	5% 1/4W	21793	001737
R70	000514	RES	CARBON	510 K	5% 1/4W	81349	RC07GF514J
R71	040235	POT	CERMET	100 K	10% 3/4W	73138	89PR100K
R72	040232	POT	CERMET	10 K	10%	73138	89PR10K
R73	040235	POT	CERMET	100 K	10% 3/4W	73138	89PR100K
TP1	600786	POST	MACHINE APPLIED STRIP			00779	1-87022-0
TP2	600786	POST	MACHINE APPLIED STRIP			00779	1-87022-0
TP3	600786	POST	MACHINE APPLIED STRIP			00779	1-87022-0
TP4	600786	POST	MACHINE APPLIED STRIP			00779	1-87022-0
TP5	600786	POST	MACHINE APPLIED STRIP			00779	1-87022-0
U1	230563	IC	LINEAR			27014	LM340LAZ-15
U2	230562	IC	LINEAR			27014	LM320Z-15

404017 – Assy., GPIB OPTION

REF DES	RACAL-DANA P/N	DESCRIPTION	FSC	MANU P/N
U17	230523	IC - Memory - U17		SYP2316B

REF DES	RACAL-DANA P/N	DESCRIPTION					FSC	MANU P/N
C1	110126	CAP	TANTA	6.8 MFD	35 V	20%	05397	T368B685M035AS
C2	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C3	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C4	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C5	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C6	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C7	100124	CAP	CERAM	330 PFD	1000 V	20%	56289	C023B102E331M
C8	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C9	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C10	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C11	100071	CAP	CERAM	.001 MFD	1000 V	20%	56289	C023B102E102M
R1	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R2	000510	RES	CARBON	51 OHM		5% 1/4W	81349	RC07GF510J
R3	000510	RES	CARBON	51 OHM		5% 1/4W	81349	RC07GF510J
U1	230246	INTEGRATED CIRCUIT			MC3440P		04713	MC3440P
U2	230246	INTEGRATED CIRCUIT			MC3440P		04713	MC3440P
U3	230246	INTEGRATED CIRCUIT			MC3440P		04713	MC3440P
U4	230246	INTEGRATED CIRCUIT			MC3440P		04713	MC3440P
U5	230356	INTEGRATED CIRCUIT			74LS175		27014	74LS175
U6	230356	INTEGRATED CIRCUIT			74LS175		27014	74LS175
U7	230194	INTEGRATED CIRCUIT			SN74LS74N		01295	SN74LS74N
U8	230368	INTEGRATED CIRCUIT			74LS138		27014	74LS138
U9	230194	INTEGRATED CIRCUIT			SN74LS74N		01295	SN74LS74N
U10	230194	INTEGRATED CIRCUIT			SN74LS74N		01295	SN74LS74N
U11	230193	INTEGRATED CIRCUIT			SN74LS00N		01295	SN74LS00N
U12	230193	INTEGRATED CIRCUIT			SN74LS00N		01295	SN74LS00N
U13	230368	INTEGRATED CIRCUIT			74LS138		27014	74LS138
U14	230356	INTEGRATED CIRCUIT			74LS175		27014	74LS175
U15	230382	INTEGRATED CIRCUIT			74LS161AN		27014	76LS161AN
U16	230382	INTEGRATED CIRCUIT			74LS161AN		27014	76LS161AN
U17	230330	INTEGRATED CIRCUIT			74LS367		01295	74LS367
U18	230381	INTEGRATED CIRCUIT			74LS136J		27014	74LS136J
U19	230359	INTEGRATED CIRCUIT			DM74LS151N		27014	DM74LS151N
U20	230330	INTEGRATED CIRCUIT			74LS367		01295	74LS367
U21	230330	INTEGRATED CIRCUIT			74LS367		01295	74LS367
U22	230330	INTEGRATED CIRCUIT			74LS367		01295	74LS367
U23	230194	INTEGRATED CIRCUIT			SN74LS74N		01295	SN74LS74N
U24	230194	INTEGRATED CIRCUIT			SN74LS74N		01295	SN74LS74N
U25	230381	INTEGRATED CIRCUIT			74LS136J		27014	74LS136J
U26	230248	INTEGRATED CIRCUIT			SN74LS10N		01295	SN74LS10N
U27	230368	INTEGRATED CIRCUIT			74LS138		27014	74LS138
U28	230359	INTEGRATED CIRCUIT			DM74LS151N		27014	DN174LS151N
U29	230359	INTEGRATED CIRCUIT			DM74LS151N		27014	DN174LS151N
U30	230372	INTEGRATED CIRCUIT			DM74LS287		27014	DM74LS287
U31	230387	INTEGRATED PROM		"U31"	HM7611		34371	HM7611
Z1	080020	RES	CERMET	10 K	NETWORK 8P,7R	2%	11236	750-81-R10KΩ
Z2	080020	RES	CERMET	10 K	NETWORK 8P,7R	2%	11236	750-81-R10KΩ

404018 – Assy., CABLE, GPIB

REF DES	RACAL-DANA P/N	DESCRIPTION	FSC	MANU P/N
J213	600835	CONN 24 P	00779	2-552273-1

401616 – Assy., PCB, PRE-AMPLIFIER

REF DES	RACAL-DANA P/N	DESCRIPTION	FSC	MANU P/N
AR1	230379	IC H.V. OP AMP MC1436G	04713	MC1436G
C1	100027	CAP CERAM .1 MFD 100 V 20%	72982	845-000-X5V0104Z
C2	110137	CAP TANTA .47 MFD 35 V 20%	05397	T368A474M035AS
C3	120134	CAP MYLAR 1 MFD 200 V 10%	19396	MF1200LL
C4	120026	CAP MYLAR .47 MFD 100 V 10%	27556	SA2B474K
C5	101175	CAP CERAM 220 PFD 500 V 10%	71471	SCD1X5F
C6	101175	CAP CERAM 220 PFD 500 V 10%	71471	SCD1X5F
C7	100027	CAP CERAM .1 MFD 100 V 20%	72982	845-000-X5V0104Z
C8	100027	CAP CERAM .1 MFD 100 V 20%	72982	845-000-X5V0104Z
C9	100027	CAP CERAM .1 MFD 100 V 20%	72982	845-000-X5V0104Z
C10	100027	CAP CERAM .1 MFD 100 V 20%	72982	845-000-X5V0104Z
C11	110020	CAP TANTA 10 MFD 35 V 10%	05397	T310C106K035AS
C12	120348	CAP POLY 1.5 MFD 200 V 5%	27556	GA2C155J
C13	100017	CAP CERAM .01 MFD 100 V 20%	56289	C023B101F103M
C14	100017	CAP CERAM .01 MFD 100 V 20%	56289	C023B101F103M
C15	120291	CAP MYLAR .27 MFD 100 V 20%	73445	C281AH/A270K
C16	130042	CAP GLASS 2.7 PFD 500 V 10%	14674	CYFM10C2R7
C17	120348	CAP POLY 1.5 MFD 200 V 5%	27556	GA2C155J
C18	110145	CAP CERAM 100 PFD 500 V 10%	04222	TCD-DI-1N5600-100
CR1	211083	DIODE SILICO 1N916B	81349	1N916B
CR2	211083	DIODE SILICO 1N916B	81349	1N916B
CR3	211083	DIODE SILICO 1N916B	81349	1N916B
CR4	220049	DIODE ZENER 1N957B 5%	81349	1N957B
K1	310112	RELAY 28 V	26806	AZ421-467-204
Q1	200204	TRANS DUAL 2N3957	81349	2N3957
Q2	200200	TRANS NPN 200200	21793	200200
Q3	200200	TRANS NPN 200200	21793	200200
Q4	200206	TRANS FET 3N138	80131	3N138
Q5	200206	TRANS FET 3N138	80131	3N138
Q6	200068	TRANS PNP 2N4250	80131	2N4250
Q7	200253	TRANS SILICO NPN MPS-A18	04713	MPS-A18
Q8	200200	TRANS NPN 200200	21793	200200
Q9	200200	TRANS NPN 200200	21793	200200
R1	000101	RES CARBON 100 OHM 5% 1/4W	81349	RC07GF101J
R2	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R3	000105	RES CARBON 1 M 5% 1/4W	81349	RC07GF105J

401616 – Assy., PCB, PRE-AMPLIFIER continued

REF DES	RACAL-DANA P/N	DESCRIPTION				FSC	MANU P/N
R4	000912	RES	CARBON	9.1 K	5% 1/4W	81349	RC07GF912J
R5	000825	RES	CARBON	8.2 M	5% 1/4W	81349	RC07GF825J
R6	000825	RES	CARBON	8.2 M	5% 1/4W	81349	RC07GF825J
R7	000101	RES	CARBON	100 OHM	5% 1/4W	81349	RC07GF101J
R8	000333	RES	CARBON	33 K	5% 1/4W	81349	RC07GF333J
R9	000334	RES	CARBON	330 K	5% 1/4W	81349	RC07GF334J
R10	000681	RES	CARBON	680 OHM	5% 1/4W	81349	RC07GF681J
R11	000223	RES	CARBON	22 K	5% 1/4W	81349	RC07GF223J
R12	000105	RES	CARBON	1 M	5% 1/4W	81349	RC07GF105J
R13	000105	RES	CARBON	1 M	5% 1/4W	81349	RC07GF105J
R14	020665	RES	WW	9.9 K	1% 3W	91637	RS-2B
R15	020665	RES	WW	9.9 K	1% 3W	91637	RS-2B
R16	000680	RES	CARBON	68 OHM	5% 1/4W	81349	RC07GF680J
R17	000104	RES	CARBON	100 K	5% 1/4W	81349	RC07GF104J
R18	000104	RES	CARBON	100 K	5% 1/4W	81349	RC07GF104J
R19	000473	RES	CARBON	47 K	5% 1/4W	81349	RC07GF473J
R22	000912	RES	CARBON	9.1 K	5% 1/4W	81349	RC07GF912J
R26	000473	RES	CARBON	47 K	5% 1/4W	81349	RC07GF473J
R27	040239	POT	CERMET	1 M	20%	73138	89PR1M
R28	020665	RES	WW	9.9 K	1% 3W	91637	RS-2B
R29	020665	RES	WW	9.9 K	1% 3W	91637	RS-2B
R30	000513	RES	CARBON	51 K	5% 1/4W	81349	RC07GF513J
R31	000152	RES	CARBON	1.5 K	5% 1/4W	81349	RC07GF152J

401622 – Assy., PCB, FAST DIGITIZER

REF DES	RACAL-DANA P/N	DESCRIPTION	FSC	MANU P/N
C1	101175	CAP CERAM 220 PFD 500 V 10%	71471	SCD1X5F
C2	100019	CAP CERAM .002 MFD 1000 V 10%	56289	C023B102F202M
C3	101175	CAP CERAM 220 PFD 500 V 10%	71471	SCD1X5F
C4	100017	CAP CERAM .01 MFD 100 V 20%	56289	C023B101F103M
C5	100017	CAP CERAM .01 MFD 100 V 20%	56289	C023B101F103M
C6	101175	CAP CERAM 220 PFD 500 V 10%	71471	SCD1X5F
C7	110126	CAP TANTA 6.8 MFD 35 V 20%	05397	T368B685M035AS
C8	110126	CAP TANTA 6.8 MFD 35 V 20%	05397	T368B685M035AS
C9	101175	CAP CERAM 220 PFD 500 V 10%	71471	SCD1X5F
C10	110126	CAP TANTA 6.8 MFD 35 V 20%	05397	T368B685M035AS
C11	110126	CAP TANTA 6.8 MFD 35 V 20%	05397	T368B685M035AS
C12	101175	CAP CERAM 220 PFD 500 V 10%	71471	SCD1X5F
C13	100017	CAP CERAM .01 MFD 100 V 20%	56289	C023B101F103M
C14	100017	CAP CERAM .01 MFD 100 V 20%	56289	C023B101F103M
C15	110129	CAP TANTA .1 MFD 35 V 20%	05397	T368A104M035AS
C16	100017	CAP CERAM .01 MFD 100 V 20%	56289	C023B101F103M
CR1	211083	DIODE SILICO IN916B	81349	IN916B
CR2	211083	DIODE SILICO IN916B	81349	IN916B
Q1	200037	TRANS SILICO NPN 2N3646	80131	2N3646
Q2	200099	TRANS PNP 2N4258	81349	2N4258
Q3	200037	TRANS SILICO NPN 2N3646	80131	2N3646
Q4	200037	TRANS SILICO NPN 2N3646	80131	2N3646
R1	000203	RES CARBON 20 K 5% 1/4W	81349	RC07GF203J
R2	000202	RES CARBON 2 K 5% 1/4W	81349	RC07GF202J
R3	000202	RES CARBON 2 K 5% 1/4W	81349	RC07GF202J
R4	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R5	000242	RES CARBON 2.4 K 5% 1/4W	81349	RC07GF242J
R6	000102	RES CARBON 1 K 5% 1/4W	81349	RC07GF102J
R7	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R8	000271	RES CARBON 270 OHM 5% 1/4W	81349	RC07GF271J
R9	010650	RES METAL 1 M 1% 1/10W	81349	RN55E1004F
R10	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R11	000202	RES CARBON 2 K 5% 1/4W	81349	RC07GF202J
R12	010951	RES METAL 365 K 1% 1/10W	81349	RN55C3653F
R13	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R14	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R15	000181	RES CARBON 180 OHM 5% 1/4W	81349	RC07GF181J
R16	000200	RES CARBON 20 OHM 5% 1/4W	81349	RC07GF200J
R17	000302	RES CARBON 3 K 5% 1/4W	81349	RC07GF302J

401622, Assy., PCB, FAST DIGITIZER *continued*

REF DES	RACAL-DANA P/N	DESCRIPTION	FSC	MANU P/N
R18	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R19	000202	RES CARBON 2 K 5% 1/4W	81349	RC07GF202J
R20	040210	POT CERMET 100 K 20% 1W	11237	360S104B
R21	040210	POT CERMET 100 K 20% 1W	11237	360S104B
R22	010631	RES METAL 10.2 K 1% 1/10W	81349	RN55C1022F
T1	300087	TRANSFORMER PULSE	21793	300087
U1	230389	INTEGRATED CIRCUIT ADC-80AG-12	13919	ADC-80AG-12
U2	230237	INTEGRATED CIRCUIT SN74LS123N	01295	SN74LS123N
U3	250006	HIGH SPEED OPTICAL ISOLATOR HP5082-4351	50434	HP5082-4351
U4	230330	INTEGRATED CIRCUIT 74LS367	01295	74LS367
U5	230330	INTEGRATED CIRCUIT 74LS367	01295	74LS367
U6	230330	INTEGRATED CIRCUIT 74LS367	01295	74LS367
U7	230237	INTEGRATED CIRCUIT SN74LS123N	01295	SN74LS123N
U8	230193	INTEGRATED CIRCUIT SN74LS00N	01295	SN74LS00N
U9	230192	INTEGRATED CIRCUIT 14 DIP, INVERTER	01295	SN74LS05N
U10	250006	HIGH SPEED OPTICAL ISOLATOR HP5082-4351	50434	HP5082-4351
U11	230234	INTEGRATED CIRCUIT SN74LS04N	01295	SN74LS04N
U12	230510	INTEGRATED CIRCUIT 74LS164		74LS164
U13	230234	INTEGRATED CIRCUIT SN74LS04N	01295	SN74LS04N
U14	230510	INTEGRATED CIRCUIT 74LS164		74LS164
U15	230193	INTEGRATED CIRCUIT SN74LS00N	01295	SN74LS00N

404022 – Assy., CABLE, FAST DIGITIZER

REF DES	RACAL-DANA P/N	DESCRIPTION	FSC	MANU P/N
J208	600167	CONN 25 S	71785	DB-25S

401606 – Assy., PCB, RATIO SWITCHING

REF DES	RACAL-DANA P/N	DESCRIPTION					FSC	MANU P/N
C1	110140	CAP	TANTA	47 MFD	6 V	20%	05397	T368B476M006AS
C2	120308	CAP	POLY	.047 MFD	250 V	10%	73445	C280MAE/A47K
CR1	211083	DIODE	SILICO		1N916B		81349	1N916B
CR2	220015	DIODE	SILICO, ZENER		1N967B		81349	1N967B
CR3	220015	DIODE	SILICO, ZENER		1N967B		81349	1N967B
CR4	220015	DIODE	SILICO, ZENER		1N967B		81349	1N967B
CR5	220015	DIODE	SILICO, ZENER		1N967B		81349	1N967B
K1	310112	RELAY			28 V		26806	AZ421-467-204
Q1	200179	TRANS	FET		KE4391		27014	KE4391
Q2	200252	TRANS	J-FET		J174		27014	J174
Q3	200200	TRANS		NPN	200200		21793	200200
Q4	200200	TRANS		NPN	200200		21793	200200
R1	020715	RES	WW	1.111 K		.1% .05W	22045	J90
R2	000104	RES	CARBON	100 K		5% 1/4W	81349	RC07GF104J
R3	000104	RES	CARBON	100 K		5% 1/4W	81349	RC07GF104J
R4	000153	RES	CARBON	15 K		5% 1/4W	81349	RC07GF153J
R5	000105	RES	CARBON	1 M		5% 1/4W	81349	RC07GF105J
R6	000336	RES	CARBON	33 M		5% 1/4W	81349	RC07GF336J
R7	030015	RES	WW	100 K		1% 10W	21551	M100
R8	030015	RES	WW	100 K		1% 10W	21551	M100

401620 – Assy., PCB, SCALING AMPLIFIER

REF DES	RACAL-DANA P/N	DESCRIPTION					FSC	MANU P/N
B1	920563	BEADS	SHIELDING				02114	56-59065/4B
B2	920563	BEADS	SHIELDING				02114	56-59065/4B
C1	110141	CAP	TANTA	22 MFD	15 V	20%	05397	T368B226M015AS
C2	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C3	100100	CAP	CERAM	FSV			21793	100100
C4	100100	CAP	CERAM	FSV			21793	100100
C5	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C6	110126	CAP	TANTA	6.8 MFD	35 V	20%	05397	T368B685M035AS
C7	110140	CAP	TANTA	47 MFD	6 V	20%	05397	T368B476M006AS
C8	120274	CAP	POLY	87 PFD	500/630 V	2.5%	08257	KSO Series
C9	130115	CAP	MICA	346 PFD	500 V	2%	72136	DM15F3460G0
C10	110162	CAP	TANTA	.33 MFD	35 V	5%	05397	T368A334J035AS
C11	110162	CAP	TANTA	.33 MFD	35 V	5%	05397	T368A334J035AS
C12	120275	CAP	POLY	1000 PFD	500/630 V	2.5%	08257	KSO Series
C13	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C14	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C15	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C16	100100	CAP	CERAM	FSV			21793	100100
C17	120280	CAP	MYLAR	.22 MFD	1000 V	10%	27556	ZA2J224K
C18	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C19	100097	CAP	CERAM	12 PFD	1000 V	5%	56289	C030B102E120J
C20	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C21	130116	CAP	MICA	3900 PFD	500 V	2%	72136	DM19F392G0
C22	110129	CAP	TANTA	.1 MFD	35 V	20%	05397	T368A104M035AS
C23	110129	CAP	TANTA	.1 MFD	35 V	20%	05397	T368A104M035AS
C24	110126	CAP	TANTA	6.8 MFD	35 V	20%	05397	T368B685M035AS
C25	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C26	100100	CAP	CERAM	FSV			21793	100100
C27	130124	CAP	TRIMMER	1.2-10 PFD	250 V		52763	R-TRIKO-122-09SD
C28	130123	CAP	TRIMMER	1-3 PFD	250 V		52763	R-TRIKO-122-09SD
C29	110126	CAP	TANTA	6.8 MFD	35 V	20%	05397	T368B685M035AS
C30	100061	CAP	CERAM	39 PFD	1000 V	5%	56289	C030B102G390J
C31	100050	CAP	CERAM	2.2 PFD	1000 V	5%	56289	C030B102S2R2D
C32	110126	CAP	TANTA	6.8 MFD	35 V	20%	05397	T368B685M035AS
C33	110126	CAP	TANTA	6.8 MFD	35 V	20%	05397	T368B685M035AS
C34	101174	CAP	CERAM	.001 MFD	500 V	10%	04222	SCD-DI-2X5F-1000
C35	100077	CAP	GLASS	7.5 PFD	500 V	5%	95275	VY10CA7R5JA
C36	130125	CAP	PORCE	.8-10 PFD	250 V		91293	JMC2951
C37	100075	CAP	CERAM	10 PFD	1000 V	5%	56289	C030B102E100J
C38	130164	CAP	PORCE	5.6 PFD	500 V	5%	95275	VY10CA5R6J

401620 – Assy., PCB, SCALING AMPLIFIER continued

REF DES	RACAL-DANA P/N	DESCRIPTION					FSC	MANU P/N
C39	100085	CAP	CERAM	6.8 PFD	1000 V	5%	56289	C030B102E6R8D
C40	130125	CAP	PROCE	.8-10 PFD	250 V		91293	JMC2951
C41	110126	CAP	TANTA	6.8 MFD	35 V	20%	05397	T368B685M035AS
C42	130127	CAP	TRIMMER	10-40 PFD			52763	10S-TRIKO-24N750
C43	100081	CAP	CERAM	4.7 PFD	1000 V	5%	56289	C030B102E4R7D
C44	110140	CAP	TANTA	47 MFD	6 V	20%	05397	T368B476M006AS
C45	110140	CAP	TANTA	47 MFD	6 V	20%	05397	T368B476M006AS
C46	110140	CAP	TANTA	47 MFD	6 V	20%	05397	T368B476M006AS
C47	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C48	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
C49	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	C023B101F103M
CR1	211083	TRANS	SILICO		1N916B		81349	1N916B
CR2	220004	DIODE	SILICO, ZENER		1N961B		81349	1N961B
CR3	210017	DIODE	MATCHED PAIR		W/CR4		21793	210017
CR4	210017	DIODE	MATCHED PAIR		W/CR3		21793	210017
CR5	220086	DIODE	ZENER	1N748A	3.9 V	5%	04713	1N748A
CR6	220004	DIODE	SILICO, ZENER		1N961B		81349	1N961B
CR7	220038	DIODE	ZENER	1N959B	8.2 V	5%	81349	1N959B
CR8	210017	DIODE	MATCHED PAIR		W/CR9		21793	210017
CR9	210017	DIODE	MATCHED PAIR		W/CR8		21793	210017
CR10	200197	TRANS	SILICO	NPN	MPS-H10		04713	MPS-H10
CR11	200197	TRANS	SILICO	NPN	MPS-H10		04713	MPS-H10
K1	310078	RELAY	REED		28 V		15636	R2690-3
K2	310078	RELAY	REED		28 V		15636	R2690-3
K3	310078	RELAY	REED		28 V		15636	R2690-3
L1	310068	CHOKE	RF	1μH		10%	99800	1537-12
Q1	200197	TRANS	SILICO	NPN	MPS-H10		04713	MPS-H10
Q2	200178	TRANS		PNP	2N5910		81349	2N5910
Q3	200197	TRANS	SILICO	NPN	MPS-H10		04713	MPS-H10
Q4	200197	TRANS	SILICO	NPN	MPS-H10		04713	MPS-H10
Q5	200178	TRANS		PNP	2N5910		81349	2N5910
Q6	200197	TRANS	SILICO	NPN	MPS-H10		04713	MPS-H10
Q7	200197	TRANS	SILICO	NPN	MPS-H10		04713	MPS-H10
Q8	200197	TRANS	SILICO	NPN	MPS-H10		04713	MPS-H10
Q9	200161	TRANS	DUAL	FET	2N5454		27014	2N5454
Q10	200197	TRANS	SILICO	NPN	MPS-H10		04713	MPS-H10
R1	000473	RES	CARBON	47 K		5% 1/4W	81349	RC07GF473J
R2	010721	RES	METAL	DIAC, MATCHED SET			21793	010721
R3	000682	RES	CARBON	6.8 K		5% 1/4W	81349	RC07GF682J

401620 – Assy., PCB, SCALING AMPLIFIER continued

REF DES	RACAL-DANA P/N	DESCRIPTION				FSC	MANU P/N
R4	000472	RES	CARBON	4.7 K	5% 1/4W	81349	RC07GF472J
R5	000680	RES	CARBON	68 OHM	5% 1/4W	81349	RC07GF680J
R6	000621	RES	CARBON	620 OHM	5% 1/4W	81349	RC07GF621J
R7	000223	RES	CARBON	22 K	5% 1/4W	81349	RC07GF223J
R8	000152	RES	CARBON	1.5 K	5% 1/4W	81349	RC07GF152J
R9	010798	RES	METAL	82.5 OHM	1% 1/10W	81349	RN55C82R5F
R10	010721	RES	METAL	DIAC, MATCHED SET		21793	010721
R11	000301	RES	CARBON	300 OHM	5% 1/4W	81349	RC07GF301J
R12	000123	RES	CARBON	12 K	5% 1/4W	81349	RC07GF123J
R13	010583	RES	METAL	182 OHM	1% 1/10W	81349	RN55C1820F
R14	010583	RES	METAL	182 OHM	1% 1/10W	81349	RN55C1820F
R15	040258	POT	CERMET	100 OHM	20% 1/2W	73138	72XW100
R16	000680	RES	CARBON	68 OHM	5% 1/4W	81349	RC07GF680J
R17	010536	RES	METAL	100 K	1% 1/10W	81349	RN55C1003F
R18	000101	RES	CARBON	100 OHM	5% 1/4W	81349	RC07GF101J
R19	000160	RES	CARBON	16 OHM	5% 1/4W	81349	RC07GF160J
R20	010720	RES	METAL	9.09 K	.25% 1/10W	81349	RN55C9091C
R21	010813	RES	METAL	7.87 K	.1% 1/10W	81349	RN55C7871F
R22	010827	RES	METAL	8.25 K	1% 1/10W	81349	RN55C8251F
R23	000202	RES	CARBON	2 K	5% 1/4W	81349	RC07GF202J
R24	000102	RES	CARBON	1 K	5% 1/4W	81349	RC07GF102J
R25	000510	RES	CARBON	51 OHM	5% 1/4W	81349	RC07GF510J
R26	010536	RES	METAL	100 K	1% 1/10W	81349	RN55C1003F
R27	000510	RES	CARBON	51 OHM	5% 1/4W	81349	RC07GF510J
R28	000241	RES	CARBON	240 OHM	5% 1/4W	81349	RC07GF241J
R29	040228	POT	CERMET	500 OHM	10%	73138	89PR500
R30	040225	POT	CERMET	50 OHM	20%	73138	89PR50
R31	040229	POT	CERMET	1 K	10% 3/4W	73138	89PR1K
R32	010721	RES	METAL	DIAC, MATCHED SET		21793	010721
R33	010721	RES	METAL	DIAC, MATCHED SET		21793	010721
R34	010721	RES	METAL	DIAC, MATCHED SET		21793	010721
R35	000163	RES	CC	16 K	5% 1/4W	81349	RC07GF163J
R36	040239	POT	CERMET	1 M	20%	73138	89PR1M
R37	000241	RES	CARBON	240 OHM	5% 1/4W	81349	RC07GF241J
R38	000101	RES	CARBON	100 OHM	5% 1/4W	81349	RC07GF101J
R39	041179	POT	WW	5 K		02111	50-1-1-502
R40	000103	RES	CARBON	10 K	5% 1/4W	81349	RC07GF103J
U1	230322	IC		MC78L18ACP		04713	MC78L18ACP
U2	230323	IC		MC79L18ACP		04713	MC79L18ACP

401641 – Assy., SAMPLE AND HOLD DIGITIZER

REF DES	RACAL-DANA P/N	DESCRIPTION					FSC	MANU P/N
Q1	200178	TRANS	PNP				81349	2N5910
Q2	200097	TRANS	NPN				81349	2N3643
Q3	200200	TRANS	NPN				21793	200200
Q4	200097	TRANS	NPN				81349	2N3643
Q5	200200	TRANS	NPN				21793	200200
Q6	200262	TRANS	N-CHANNEL		J-FET		27014	PN4392
Q7	200262	TRANS	N-CHANNEL		J-FET		27014	PN4392
R1	000562	RES	CARBON	5.6 K		5% 1/4W	81349	RC07GF562J
R2	000102	RES	CARBON	1 K		5% 1/4W	81349	RC07GF102J
R3	000202	RES	CARBON	2 K		5% 1/4W	81349	RC07GF202J
R4	000180	RES	CARBON	18 OHM		5% 1/4W	81349	RC07GF180J
R5	000180	RES	CARBON	18 OHM		5% 1/4W	81349	RC07GF180J
R6	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R7	000472	RES	CARBON	4.7 K		5% 1/4W	81349	RC07GF472J
R8	000302	RES	CARBON	3 K		5% 1/4W	81349	RC07GF302J
R9	000271	RES	CARBON	270 OHM		5% 1/4W	81349	RC07GF271J
R10	000471	RES	CARBON	470 OHM		5% 1/4W	81349	RC07GF471J
R11	000361	RES	CARBON	360 OHM		5% 1/4W	81349	RC07GF361J
R12	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R13	000512	RES	CARBON	5.1 K		5% 1/4W	81349	RC07GF512J
R15	000472	RES	CARBON	4.7 K		5% 1/4W	81349	RC07GF472J
R16	000512	RES	CARBON	5.1 K		5% 1/4W	81349	RC07GF512J
R17	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R18	000202	RES	CARBON	2 K		5% 1/4W	81349	RC07GF202J
R19	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R20	000203	RES	CARBON	20 K		5% 1/4W	81349	RC07GF203J
R21	000102	RES	CARBON	1 K		5% 1/4W	81349	RC07GF102J
R22	010790	RES	METAL	36.5 K		1% 1/10W	81349	RN55E3652F
R23	010542	RES	METAL	100 K		1% 1/10W	81349	RN55E1003F
R24	040229	POT	CERMET	1 K		10% 3/4W	73138	89PR1K
R25	012066	RES	METAL FILM	825 K		1% 1/8W	81349	RN55E8253F
R26	040179	POT	CERMET	10 K		20% 3/4W	11237	360 Series
R27	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R28	000361	RES	CARBON	360 OHM		5% 1/4W	81349	RC07GF361J
R29	000511	RES	CARBON	510 OHM		5% 1/4W	81349	RC07GF511J
R30	000181	RES	CARBON	180 OHM		5% 1/4W	81349	RC07GF181J
R31	000302	RES	CARBON	3 K		5% 1/4W	81349	RC07GF302J
R32	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R33	040235	POT	CERMET	100 K		10% 3/4W	73138	89PR100K
R34	000101	RES	CARBON	100 OHM		5% 1/4W	81349	RC07GF101J
R35	000101	RES	CARBON	100 OHM		5% 1/4W	81349	RC07GF101J
R36	001737	RES	CARBON	FSV		5% 1/4W	21793	001737

401641 – Assy., SAMPLE AND HOLD DIGITIZER

REF DES	RACAL-DANA P/N		DESCRIPTION	FSC	MANU P/N
U1	230389	IC		13919	ADC-80AG-12
U2	230193	IC	14 DIP, NAND GATE	01295	SN74LS00N
U3	230330	IC		01295	74LS367
U4	230330	IC		01295	74LS367
U5	230330	IC		01295	74LS367
U6	230237	IC	DUAL ONE SHOT, PLASTIC	01295	SN74LS123N
U7	230193	IC	14 DIP, NAND GATE	01295	SN74LS00N
U8	230192	IC	14 DIP, INVERTER	01295	SN74LS05N
U9	230237	IC	DUAL ONE SHOT, PLASTIC	01295	SN74LS123N
U10	230234	IC	14 DIP, HEX INVERTER	01295	SN74LS04N
U11	230510	IC	8 BIT SHIFT REGISTER		74LS164
U12	230234	IC	14 DIP, HEX INVERTER	01295	SN74LS04N
U13	230510	IC	8 BIT SHIFT REGISTER		74LS164
U14	230193	IC	14 DIP, NAND GATE	01295	SN74LS00N